CDF highlights of winter conference results

Fabrizio Margaroli
University of Rome "La Sapienza"
On behalf of the CDF Collaboration



Farewell my dear

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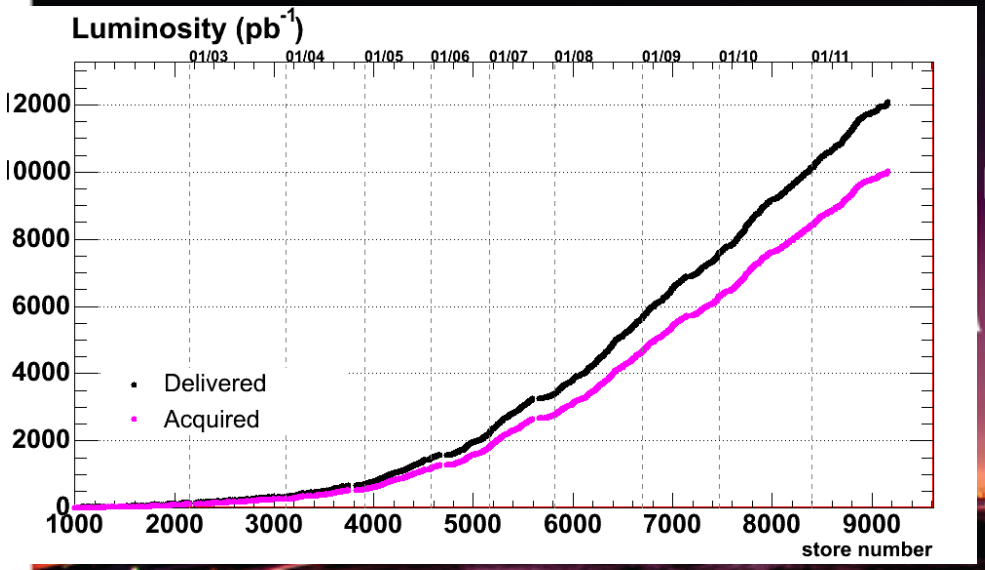
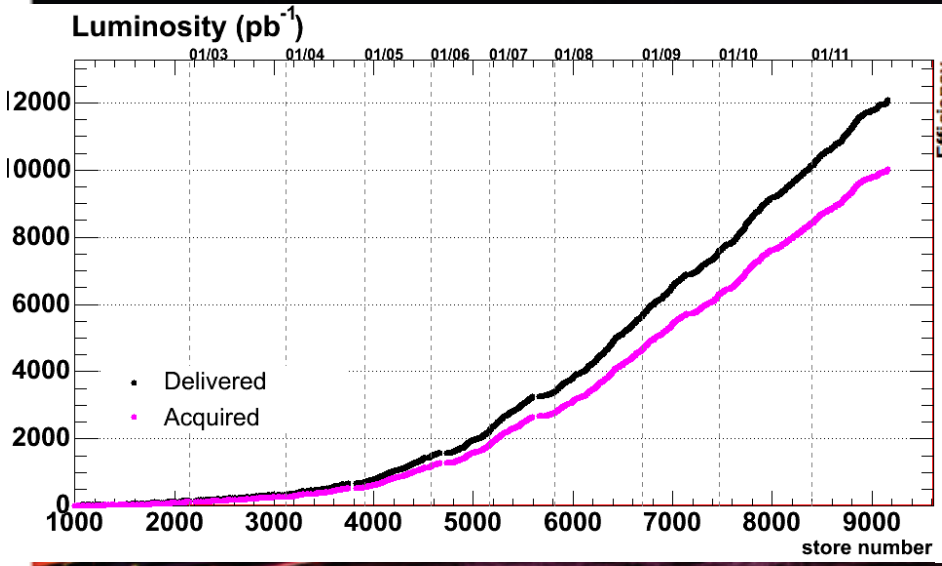
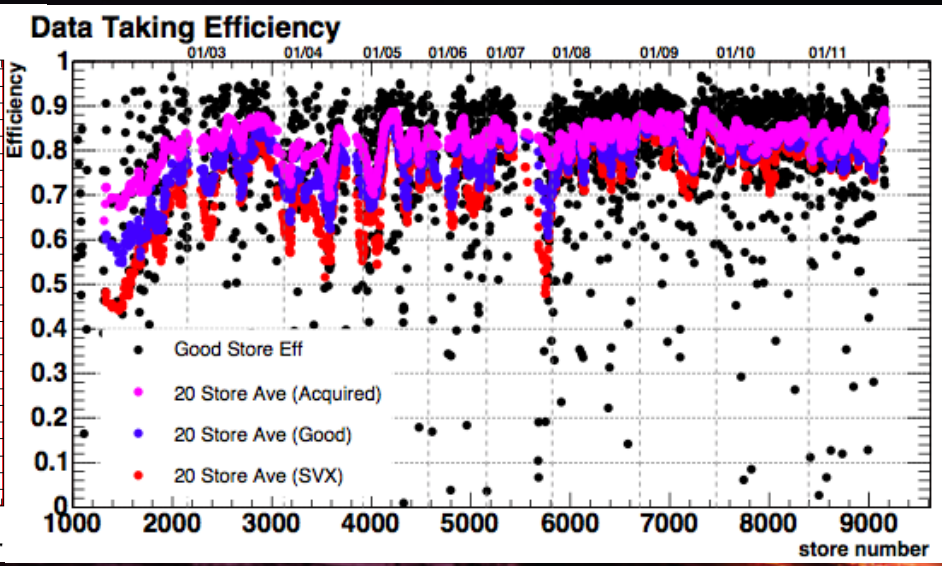


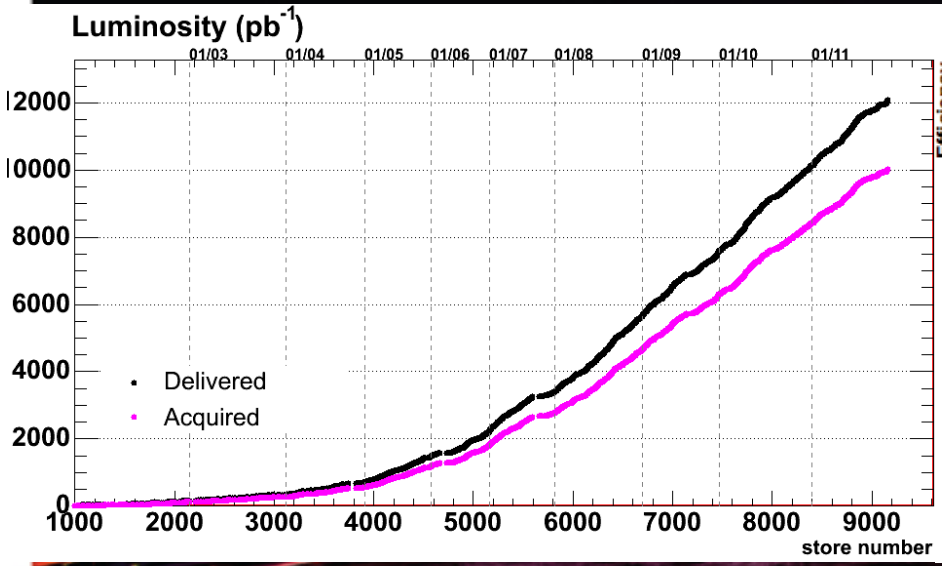
Farewell my dear

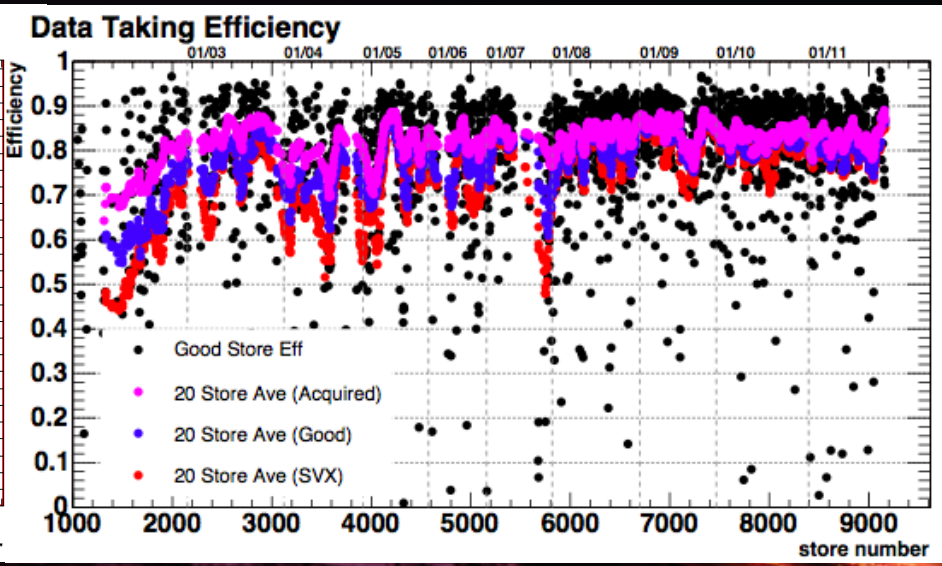




Delivered >10.0 fb^{-1}
Acquired 10 fb^{-1} (somewhat less with silicon)

Farewell my dear

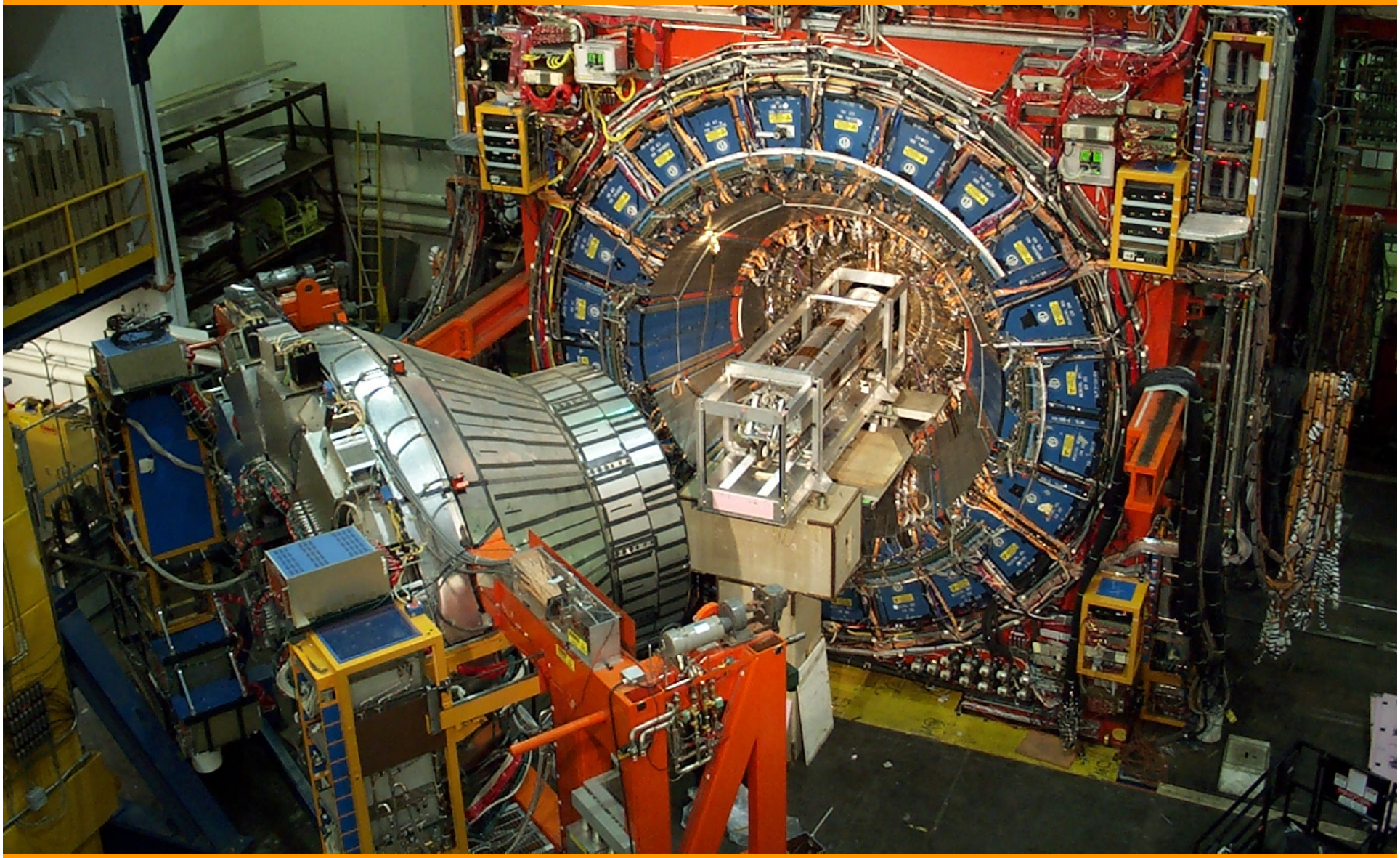




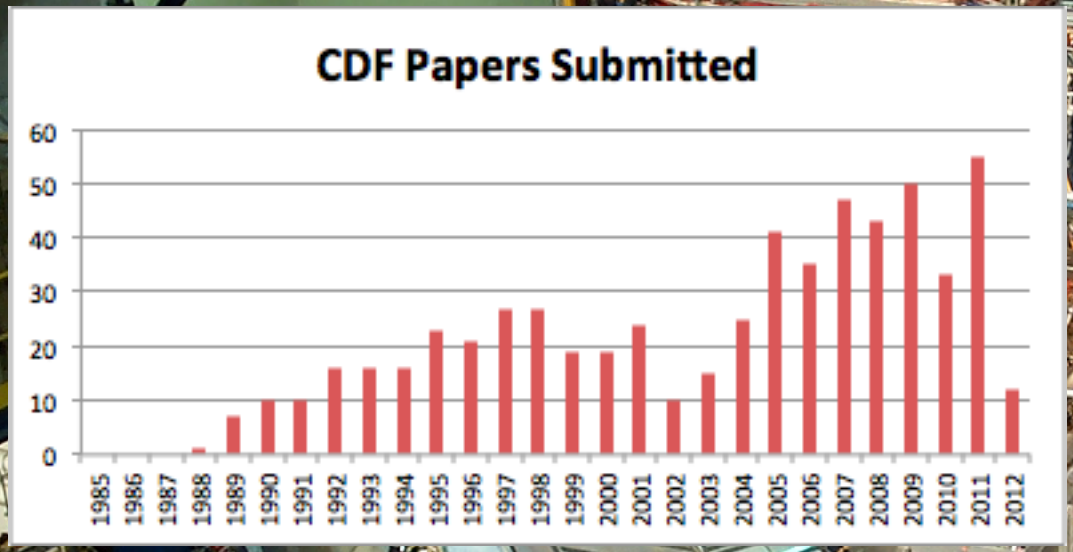
Delivered >10.0 fb^{-1}
Acquired 10 fb^{-1} (somewhat less with silicon)

Most analyses here use the
full Tevatron dataset

My 1st love

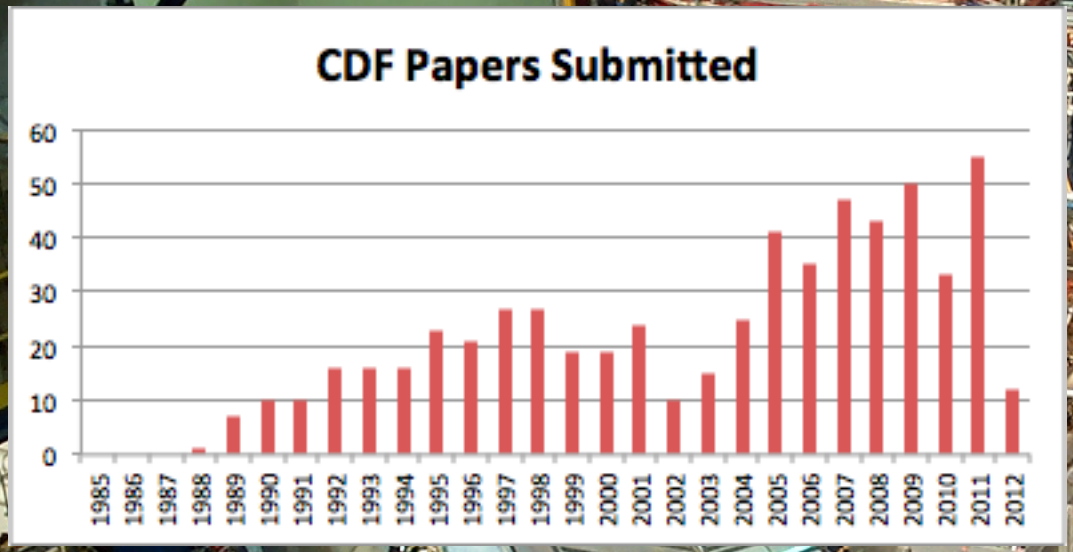


My 1st love



Over 600 papers total

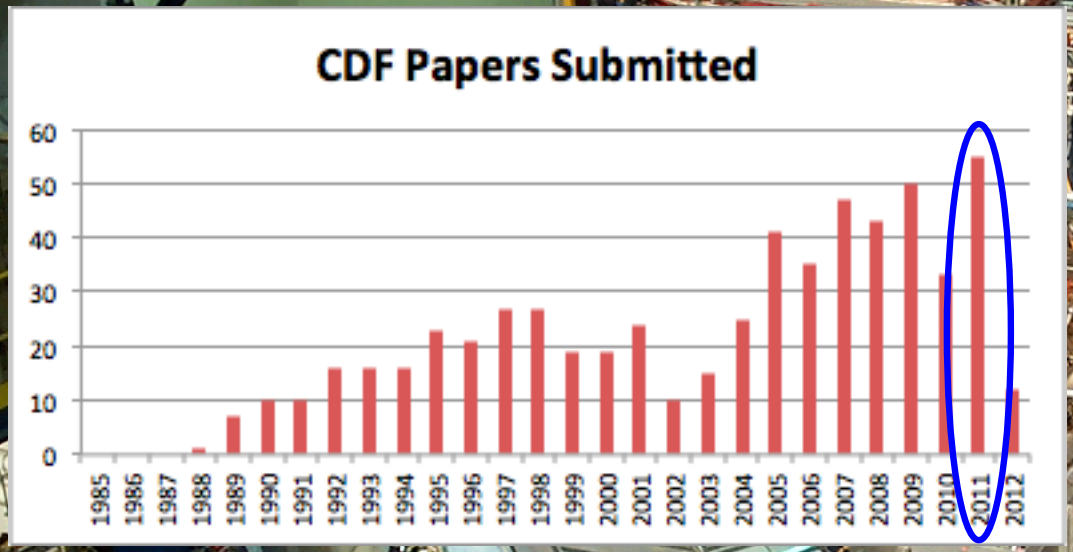
My 1st love



Over 600 papers total

Over 350 RunII papers

My 1st love



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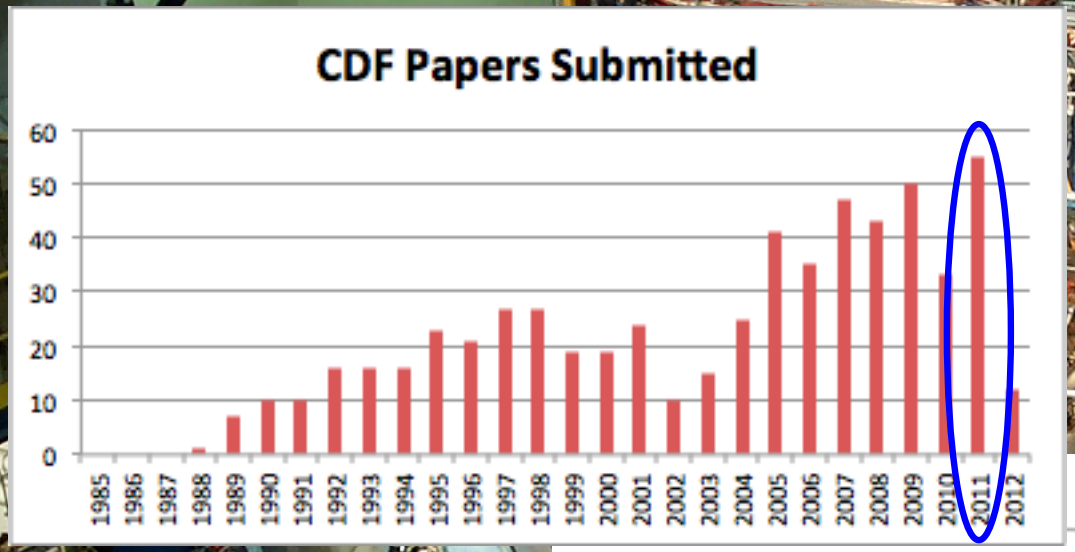
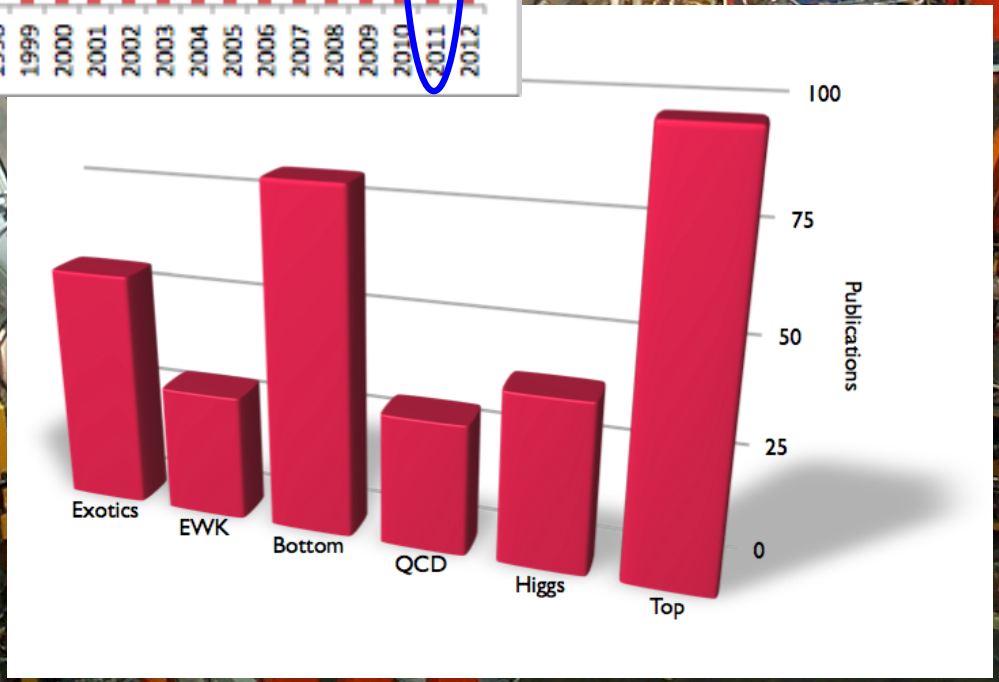


Over 600 papers total

Over 350 RunII papers



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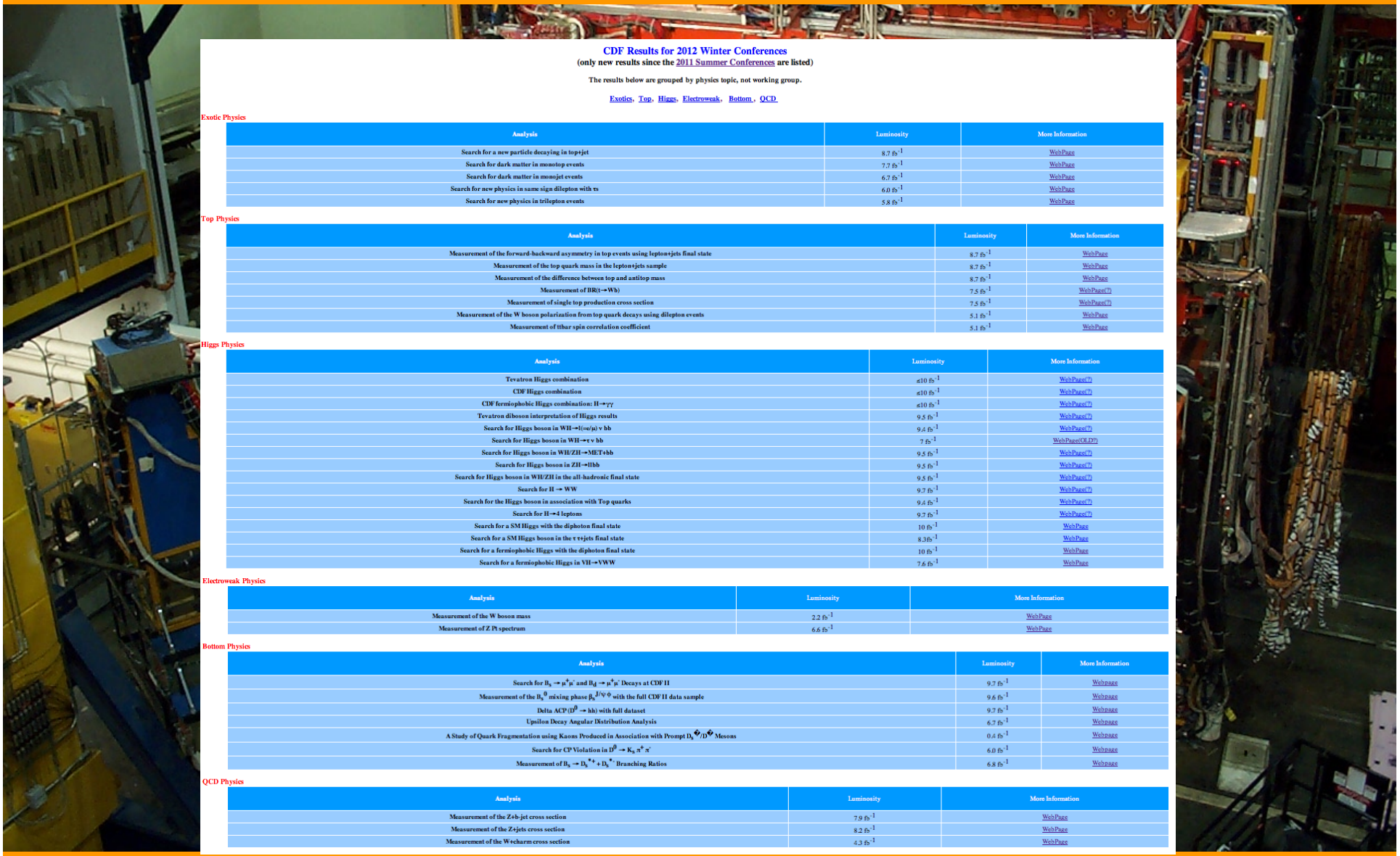

CDF Results for 2012 Winter Conferences
(only new results since the 2011 Summer Conferences are listed)

The results below are grouped by physics topic, not working group.

Exotics, Top, Higgs, Electroweak, Bottom, QCD

Exotic Physics

Analysis	Luminosity	More Information
Search for a new particle decaying in top+jet	8.7 fb^{-1}	WebPage
Search for dark matter in monotop events	7.7 fb^{-1}	WebPage
Search for dark matter in monojet events	6.7 fb^{-1}	WebPage
Search for new physics in same sign dilepton with τs	6.0 fb^{-1}	WebPage
Search for new physics in trilepton events	5.8 fb^{-1}	WebPage

Top Physics

Analysis	Luminosity	More Information
Measurement of the forward-backward asymmetry in top events using lepton+jets final state	8.7 fb^{-1}	WebPage
Measurement of the top quark mass in the lepton+jets sample	8.7 fb^{-1}	WebPage
Measurement of the difference between top and antitop mass	8.7 fb^{-1}	WebPage
Measurement of BR(t→Wb)	7.5 fb^{-1}	WebPage(?)
Measurement of single top production cross section	7.5 fb^{-1}	WebPage(?)
Measurement of the W boson polarization from top quark decays using dilepton events	5.1 fb^{-1}	WebPage
Measurement of ttbar spin correlation coefficient	5.1 fb^{-1}	WebPage

Higgs Physics

Analysis	Luminosity	More Information
Tevatron Higgs combination	≤10 fb^{-1}	WebPage(?)
CDF Higgs combination	≤10 fb^{-1}	WebPage(?)
CDF fermiophobic Higgs combination: H→γγ	≤10 fb^{-1}	WebPage(?)
Tevatron diboson interpretation of Higgs results	9.5 fb^{-1}	WebPage(?)
Search for Higgs boson in WH→l(=e/μ) ν bb	9.4 fb^{-1}	WebPage(?)
Search for Higgs boson in WH→τν bb	7 fb^{-1}	WebPage(OLD?)
Search for Higgs boson in WH/ZH→MET+bb	9.5 fb^{-1}	WebPage(?)
Search for Higgs boson in ZH→llbb	9.5 fb^{-1}	WebPage(?)
Search for Higgs boson in WH/ZH in the all-hadronic final state	9.5 fb^{-1}	WebPage(?)
Search for H → WW	9.7 fb^{-1}	WebPage(?)
Search for the Higgs boson in association with Top quarks	9.4 fb^{-1}	WebPage(?)
Search for H→4 leptons	9.7 fb^{-1}	WebPage(?)
Search for a SM Higgs with the diphoton final state	10 fb^{-1}	WebPage
Search for a SM Higgs boson in the τ τ+jets final state	8.3 fb^{-1}	WebPage
Search for a fermiophobic Higgs with the diphoton final state	10 fb^{-1}	WebPage
Search for a fermiophobic Higgs in VH→VWW	7.6 fb^{-1}	WebPage

Electroweak Physics

Analysis	Luminosity	More Information
Measurement of the W boson mass	2.2 fb^{-1}	WebPage
Measurement of Z Pt spectrum	6.6 fb^{-1}	WebPage

Bottom Physics

Analysis	Luminosity	More Information
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Measurement of the B_s^0 mixing phase $\beta_s^{J/\psi\,\phi}$ with the full CDF II data sample	9.6 fb^{-1}	Webpage
Delta ACP ($D^0 \to hh$) with full dataset	9.7 fb^{-1}	Webpage
Upsilon Decay Angular Distribution Analysis	6.7 fb^{-1}	Webpage
A Study of Quark Fragmentation using Kaons Produced in Association with Prompt $D_s^{*}/\bar{D}_s^{*}$ Mesons	0.4 fb^{-1}	Webpage
Search for CP Violation in $D^0 \to K_s\,\pi^+\pi^-$	6.0 fb^{-1}	Webpage
Measurement of $B_s \to D_s^{*+} + D_s^{*-}$ Branching Ratios	6.8 fb^{-1}	Webpage

QCD Physics

Analysis	Luminosity	More Information
Measurement of the Z+b-jet cross section	7.9 fb^{-1}	WebPage
Measurement of the Z+jets cross section	8.2 fb^{-1}	WebPage
Measurement of the W+charm cross section	4.3 fb^{-1}	WebPage

My 1st love

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Measurement of ttbar spin [illegible]	5.1 fb^{-1}	WebPage

Higgs Physics

Analysis	Luminosity	More Information
[illegible]	[illegible]	WebPage(?)
[illegible]	[illegible]	WebPage(?)
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	WebPage(OLD?)
[illegible]	[illegible]	WebPage(?)
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	WebPage(?)
[illegible]	[illegible]	WebPage(?)
[illegible]	[illegible]	WebPage
[illegible]	[illegible]	WebPage
[illegible] Higgs with th[illegible]	10 fb^{-1}	WebPage
Search for a fermiophobic Higgs [illegible]	7.6 fb^{-1}	WebPage

40+ new results
Several world bests
Many new analyses!

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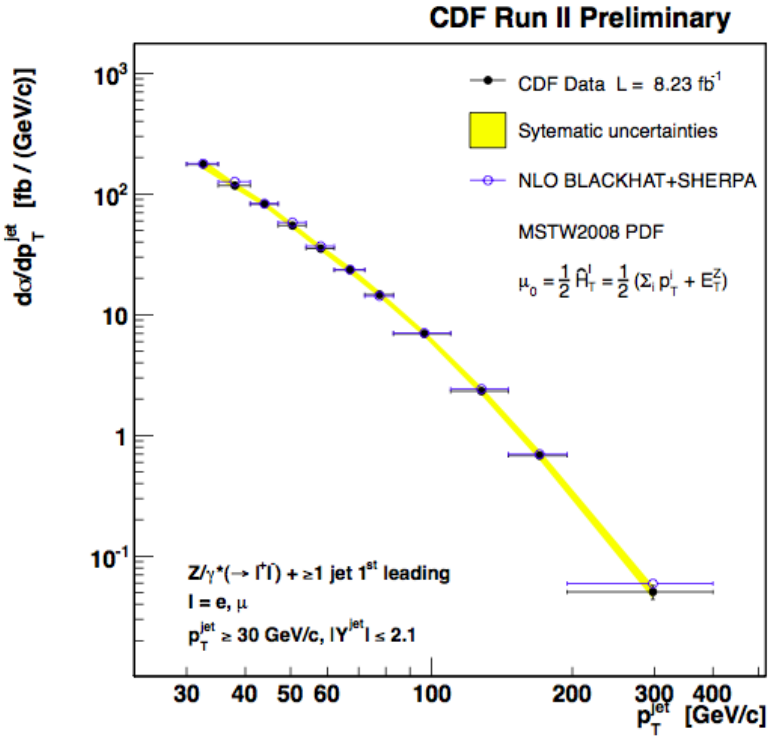
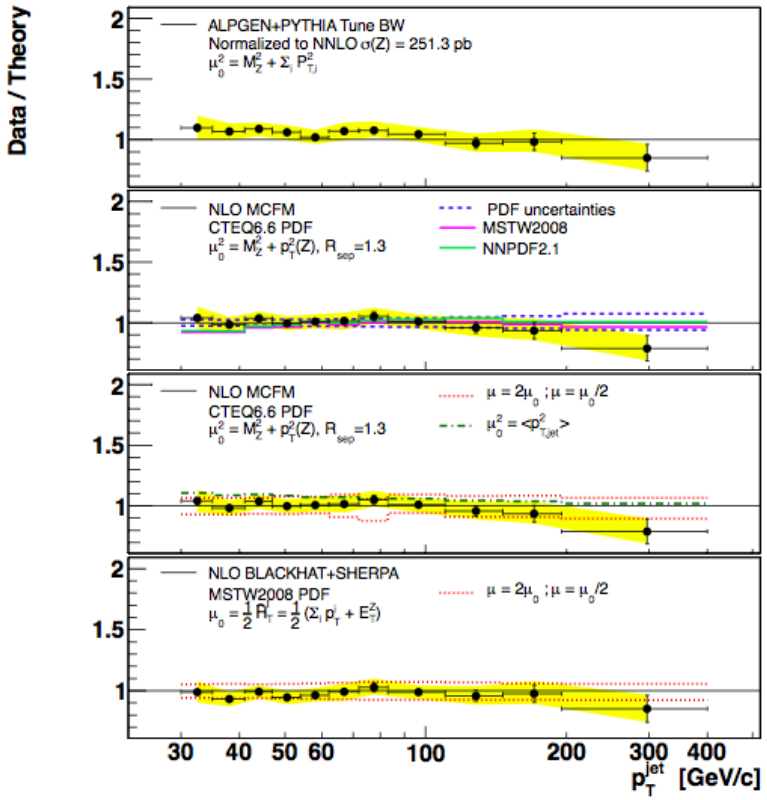
QCD

Z/γ*+ jets differential cross section

Use dielectron/dimuon final states, plus 1,2,3 or more jets

Distributions unfolded to hadron level - theory corrected to hadron level too

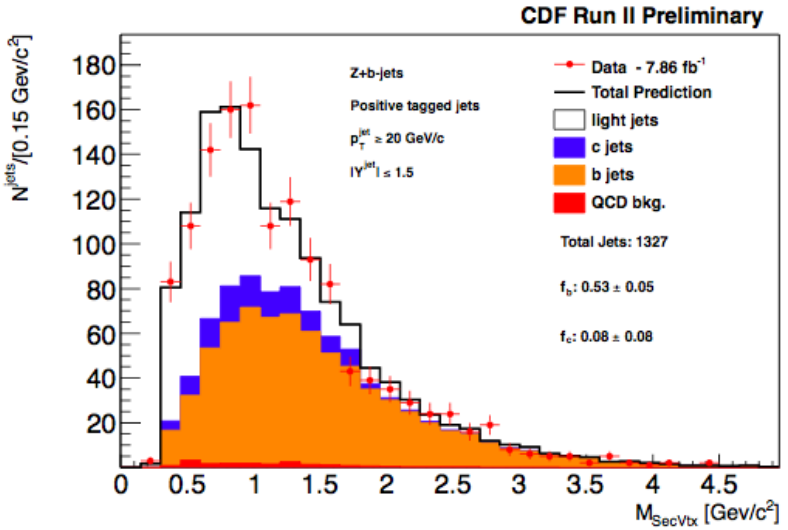




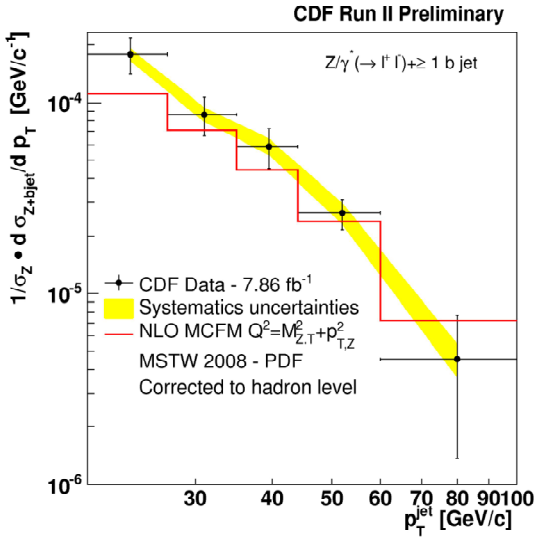
Results compared with state-of-the-art theoretical predictions and event generators.
Many more distributions obtainable at the public webpage

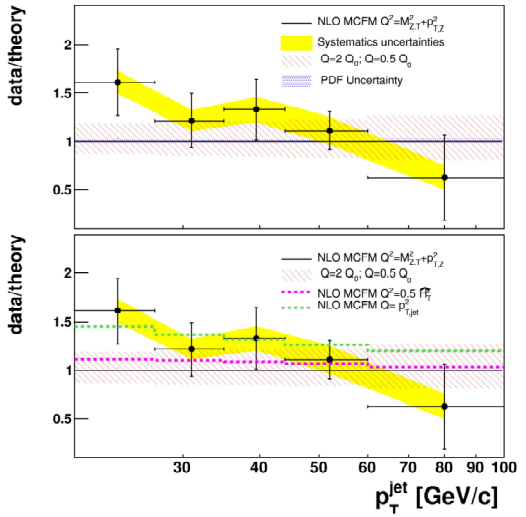
Z+bottom jets

- Measure the b-quark component of Z+jets production by fitting the vertex mass
- NN muon ID to increase acceptance
- MCFM NLO QCD calculation predict ratio Z+b/Z+j to be 0.27%. CDF measurement consistent $\frac{\sigma_{Z+bjet}}{\sigma_Z} = 0.293 \pm 0.030^{stat} \pm 0.036^{syst}\%$



- Measure differential cross sections as a function of jet Pt, jet y

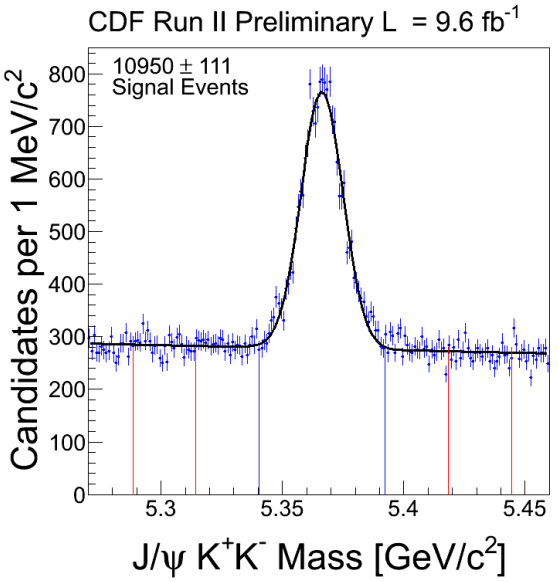




Quarks: the heavy flavors

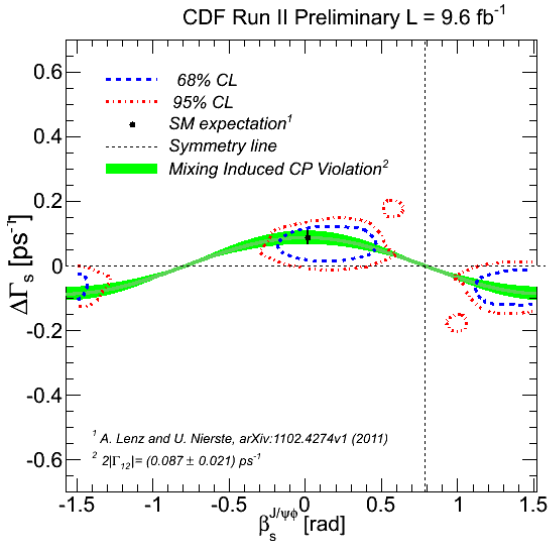
B^0_s mixing phase

- B_s^0 mixing phase expected tiny in SM. Broad class of NP models predict effective enhancements.
- 2008 Tevatron measurement: intriguing 2.2σ deviation. Softened last summer by recent updates.
- NEW: update with full Run II dataset. Reconstructed 11K $B_s^0 \rightarrow J/\psi\varphi$ decays



- Joint fit to B mass, decay-time, flavor tag, decay-angles

β_s in [-0.06, 0.30] @68% C.L.



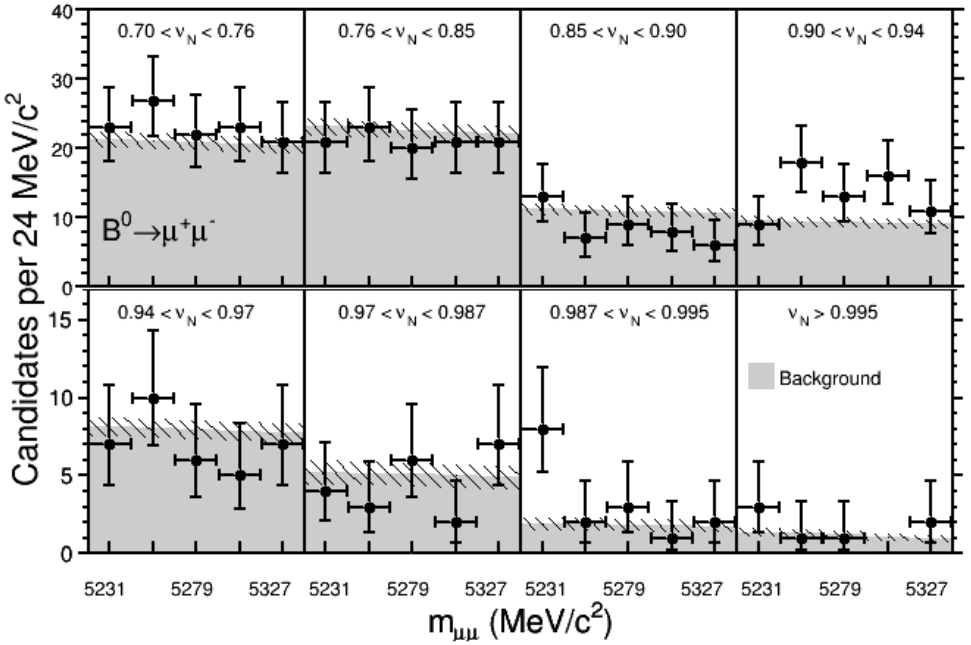
- Assuming SM CP-violation, precise measurement of decay width difference between B_s^L and B_s^H

$\Delta\Gamma_s = 0.068 \pm 0.027(\text{stat+syst})\ \text{ps}^{-1}$

$B_s \rightarrow \mu^+\mu^-$

- BR predicted small and well under control
- almost any SM extension enhances it
- CDF led experimental exploration over the past 10 years. Tightened limits over orders of magnitudes until approaching SM sensitivity.
- Summer '11: tantalizing >2.5σ deviation from bckg: fluctuation or first indication of signal ?
- now added 30% of data – analysis kept unchanged

- $B^0 \rightarrow \mu^+\mu^-$ channel supports good understanding of sample and backgrounds



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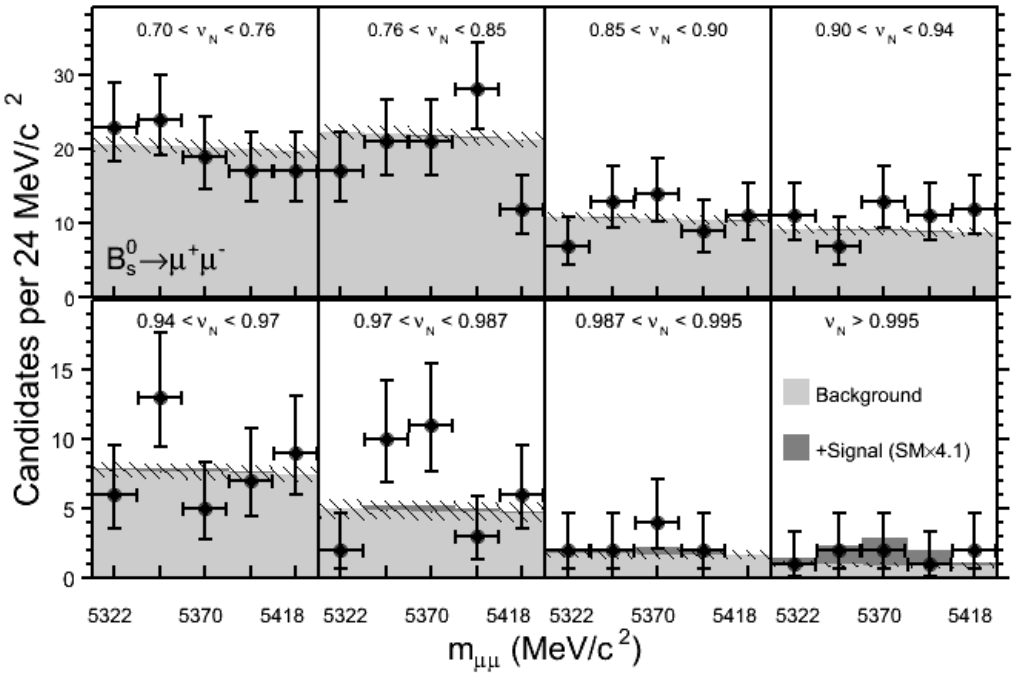


B_s Results

	All Bins	NN>0.987
Fit ($\times 10^{-8}$)	$1.3^{+0.9}_{-0.7}$	$1.0^{+0.8}_{-0.6}$
90% CL ($\times 10^{-8}$)	$0.22 < \mathcal{B} < 3.0$	$0.08 < \mathcal{B} < 2.5$
Bkg p-value	0.94%	2.1%
SM+Bkg p-value	7.1%	22.5%

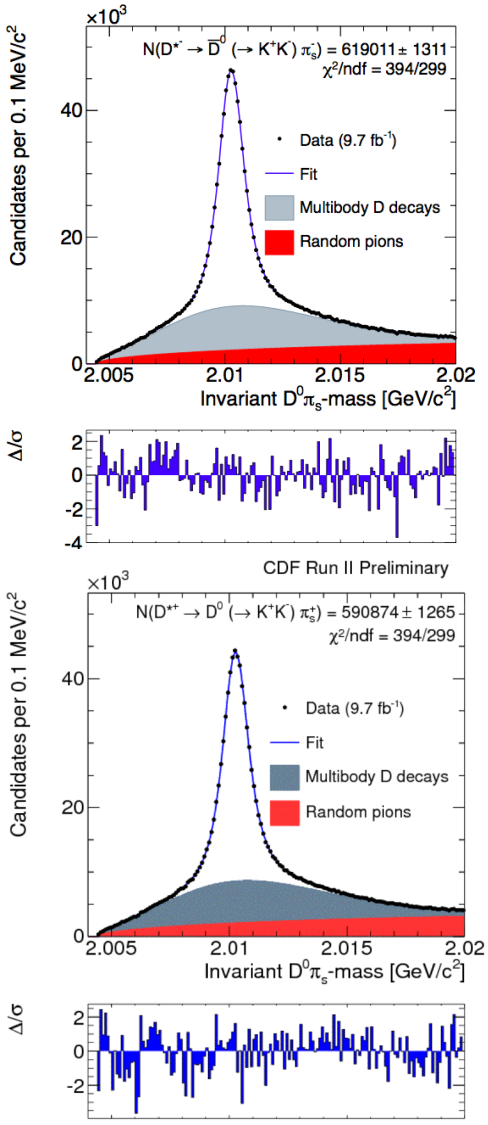
- Summer excess not strengthened, but still there at >2σ over background
- Compatible with SM and other experiments' results

Delta $A_{CP}(D^0 \to hh)$

- CPV in charm expected to be out of reach of existing experiments. Still, LHCb reported evidence:
  $\Delta A_{CP} = A_{CP}(D^0 \to KK) - A_{CP}(D^0 \to \pi\pi) =$
  $= [-0.82 \pm 0.21(\text{stat}) \pm 0.11(\text{syst})]\%$

- CP violation in charm suggestive of BSM

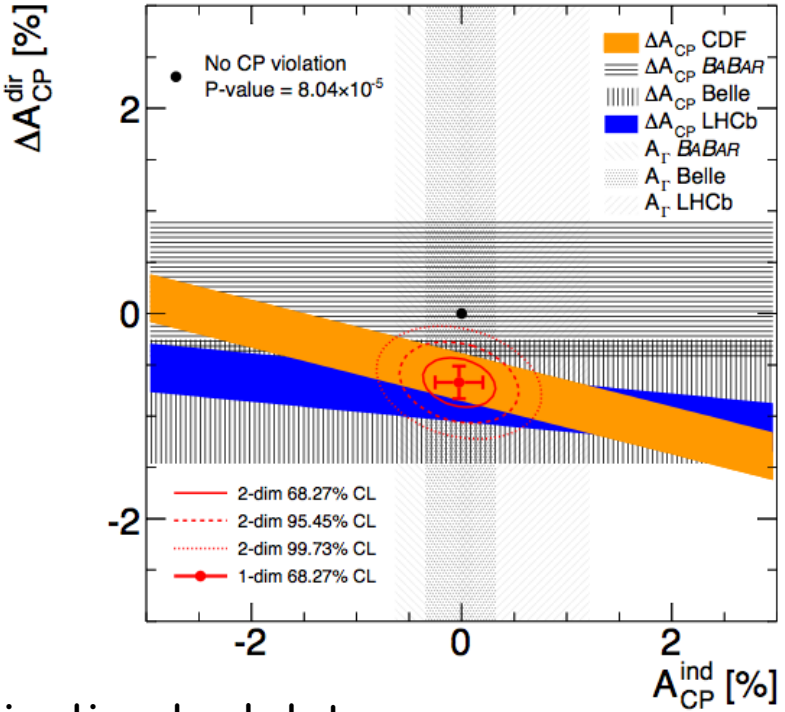
- Need independent confirmation – only CDF has sufficient sensitivity
- Building on a previous measurement (PRD.) we updated the result optimizing the selection for the measurement of the difference of asymmetries
- looking at difference of asymmetries – almost all instrumental effects cancel



Delta $A_{CP}(D^0 \to hh)$

- Result updated using full RunII data sample and improved event selection
  $\Delta A_{CP} = A_{CP}(D^0 \to KK) - A_{CP}(D^0 \to \pi\pi) = [-0.62 \pm 0.21(\text{stat}) \pm 0.10(\text{syst})]\%$

- Strong indication (2.7σ) that CP is violated in charm at the 0.5-1% level.
- Confirming the LHCb result with competitive resolution.-
- Naive LHCb+CDF combination yield direct CPV in charm at the 3.8σ level.

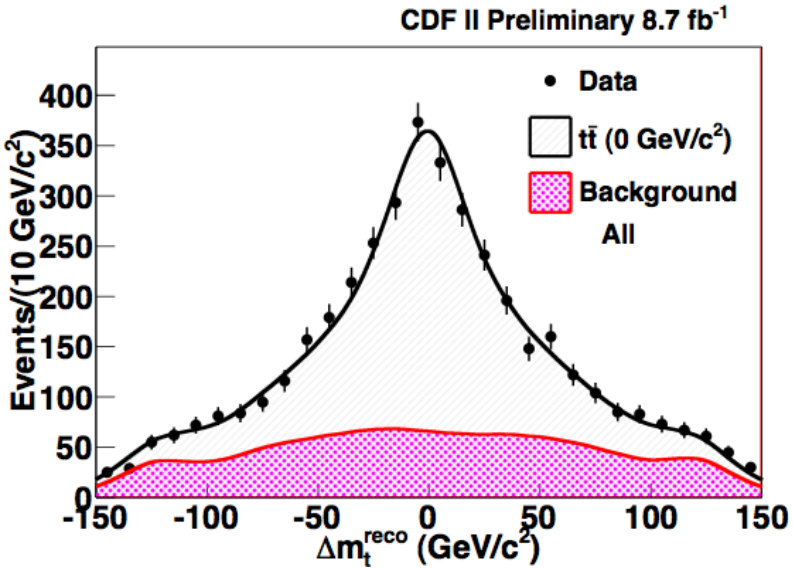


Most precise determination to date!

Quarks:the heaviest flavor

M_{top}- $M_{antitop}$ measurement

- Measurement of difference between top and antitop quarks masses tests CPT
  - Unique as it's the only quark that can be studied naked
  - systematics mostly cancel out in the difference
- Additions for this round:
  - analyze 0 tagged events
  - use advanced jet energy corrections
  - use all available data!



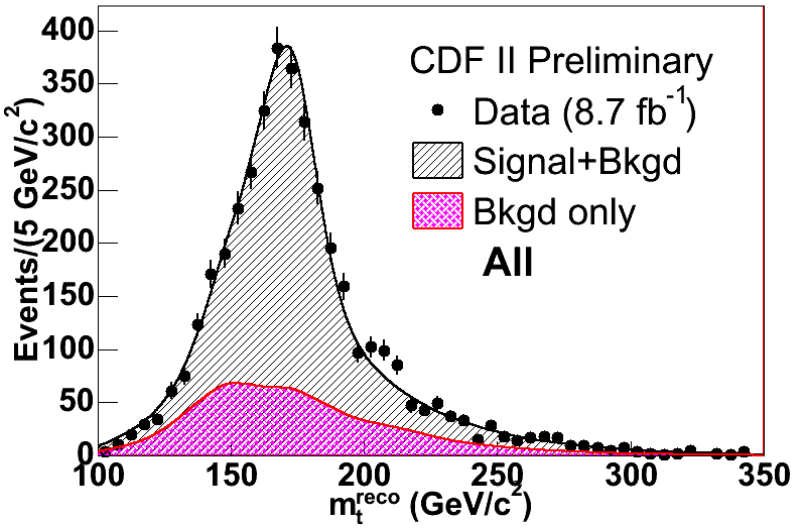
CDF II Preliminary 8.7 fb^{-1}

Systematic	GeV/c^2
Signal Modeling	0.14
Parton Showering	0.17
Next Leading Order	0.16
Jet energy scale	0.07
Parton Distribution Functions	0.12
b jet energy	0.05
$b/\bar{b}$ asymmetry	0.38
Background shape	0.20
gg fraction	0.05
Radiation	0.10
MC statistics	0.07
Lepton energy	0.06
MHI	0.05
Color Reconnection	0.23
Total systematic	0.59

Delta M_{top}= -1.95 ± 1.26 GeV/c^2

M_{top} measurement in tt→bblnuqq

- The heavies particle is still puzzling. The precise knowledge of its mass is crucial:
  - Its exact value points to Higgs boson mass, both in SM and BSM scenarios
  - Production and decay depend strongly on its mass
  - Yukawa coupling extremely close to 1 points to BSM?



M_{top}= 172.85 ± 1.10 GeV/c^2

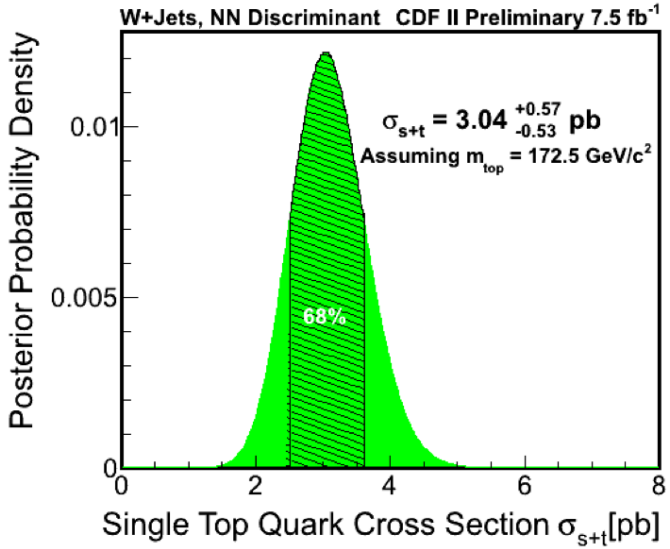
CDF II Preliminary 8.7 fb^{-1}

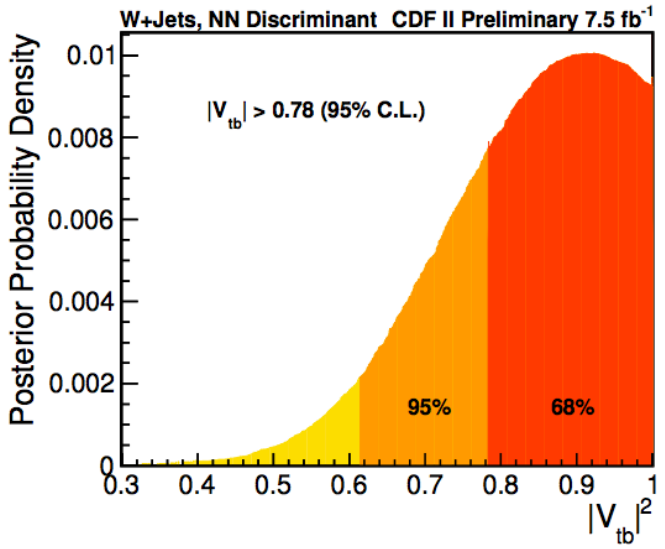
Systematic	GeV/c^2
Residual JES	0.52
Generator	0.56
Next Leading Order	0.09
PDFs	0.08
b jet energy	0.10
b tagging efficiency	0.03
Background shape	0.20
gg fraction	0.03
Radiation	0.06
MC statistics	0.05
Lepton energy	0.03
MHI	0.07
Color Reconnection	0.21
Total systematic	0.84

Single most precise determination of top mass to date

New σ(single top) measurement

- Reminders:
  - single top first observed in 09 by CDF and D0 simultaneously
  - LHC sensitive mostly to t-channel (and eventually Wt)
  - At Tevatron s- and t-channels are comparable (and Wt almost negligible)
- Now showing update of the observation analysis to 7.5fb^{-1}
  - Addition of several improvements stemming from analogous WH search





σ(s+t)=3.04 ± 0.55pb → V_{tb}=0.92 ± 0.09(ex) ± 0.05(th)

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  - s- and t-channels have sensitivity to different NP scenarios
  - Past iteration, CDF showed a 2σ discrepancy with SM predictions, and with D0's measurement

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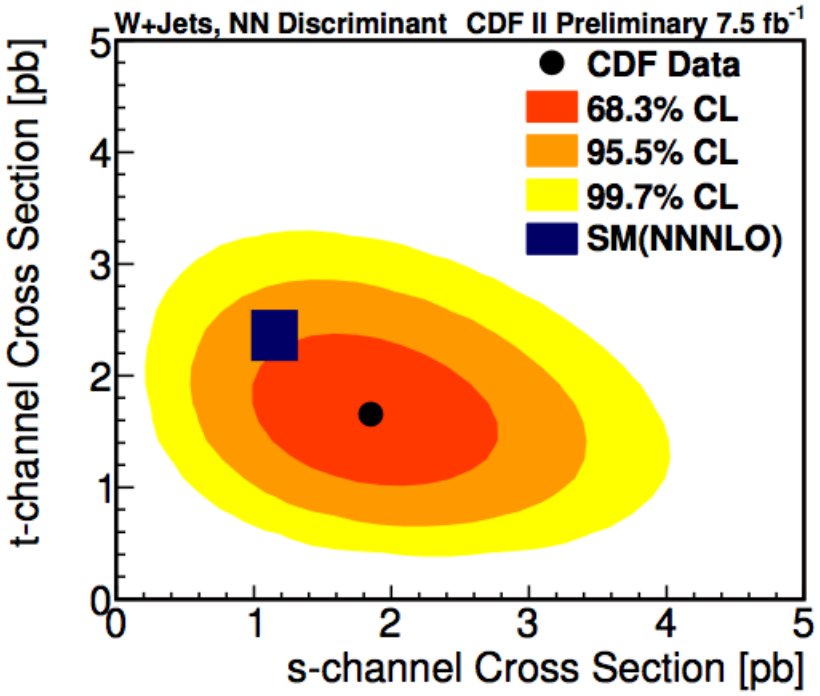
- Now more in line with SM

$\sigma(t)=1.49^{+0.48}_{-0.40}$ pb

$\sigma(s)=1.81^{+0.63}_{-0.58}$ pb

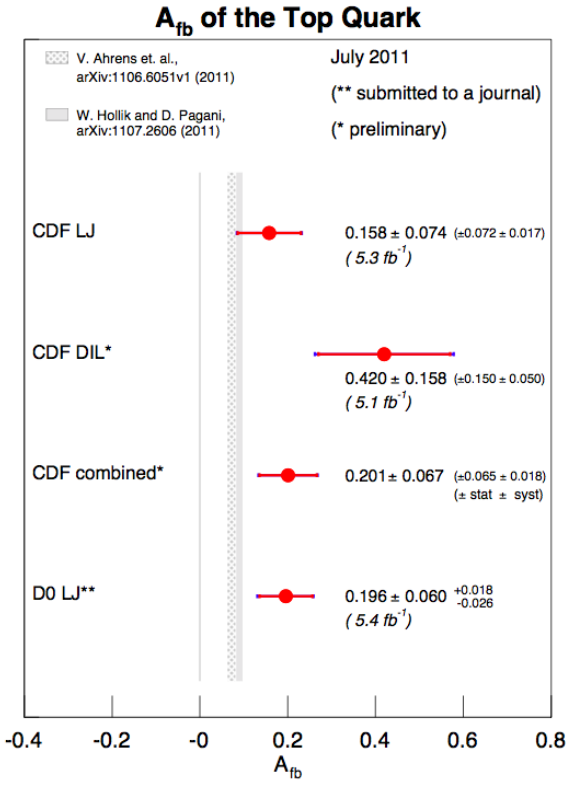
world best s-channel estimation!

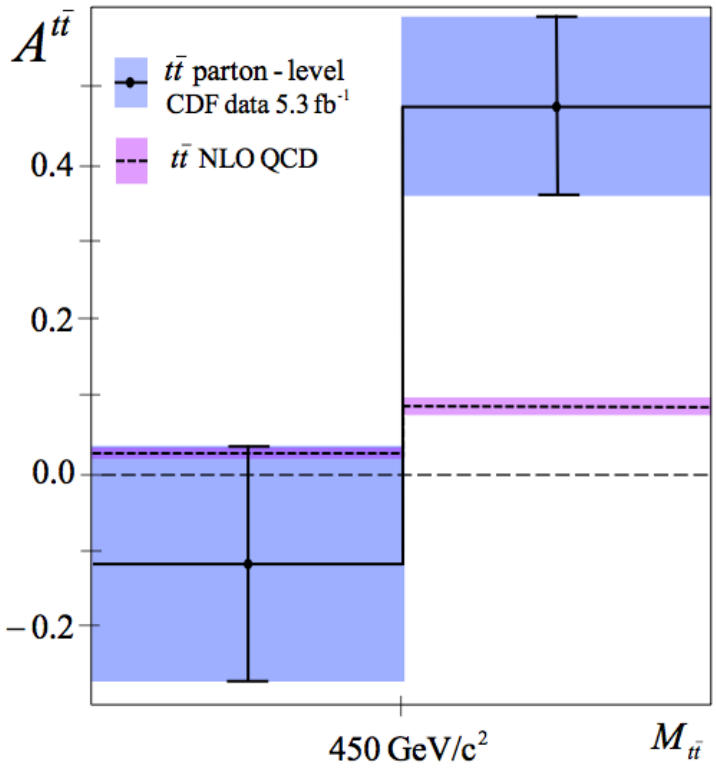


Forward-backward asymmetry

Top quark at the Tevatron are produced mostly along the proton direction.
QCD says AFB about 5%, CDF and D0 measured larger values.

- First breakthrough(>3σ) one year ago with large m(ttbar) dependence (CDF).
- Then (CDF+D0) finding large inclusive asymmetries.



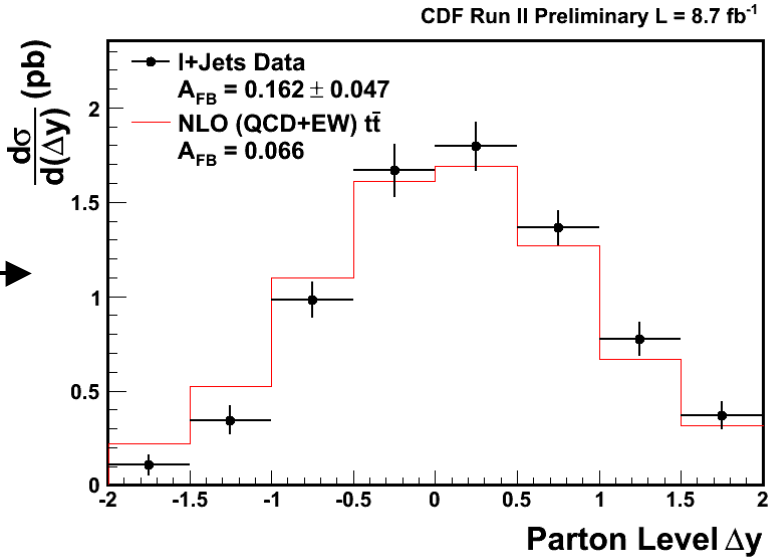


- Then improved EWK computation enhances by 20% AFB….what is going on?

AFB: the new results

Analyze full dataset, expanded signal acceptance, improved (NLO) modeling

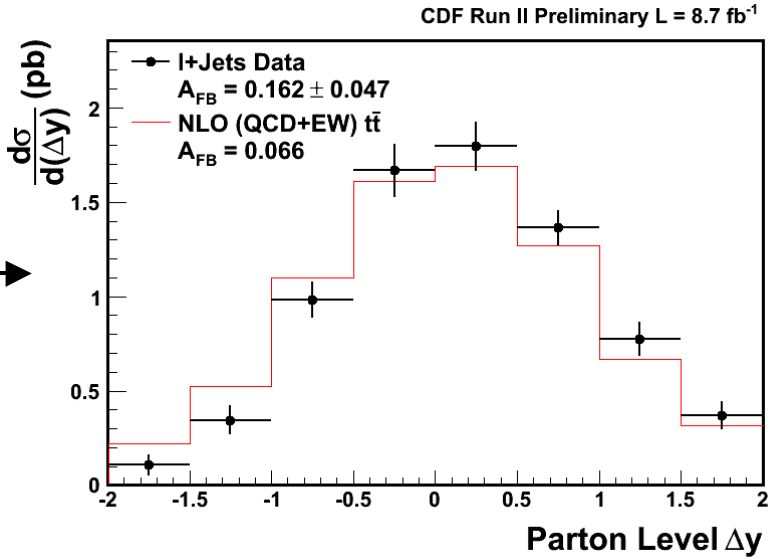
- The inclusive asymmetry is still large →

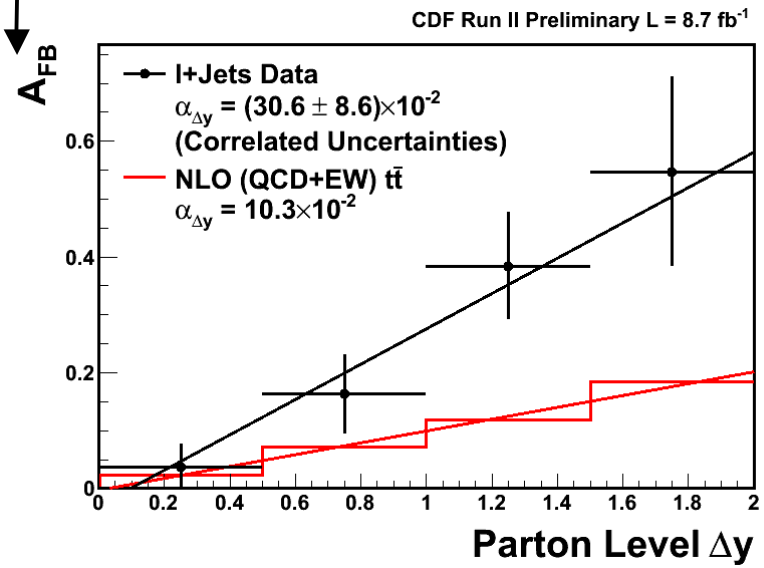


AFB: the new results

Analyze full dataset, expanded signal acceptance, improved (NLO) modeling

- The inclusive asymmetry is still large
- The deviation is still larger
  - at large DeltaY





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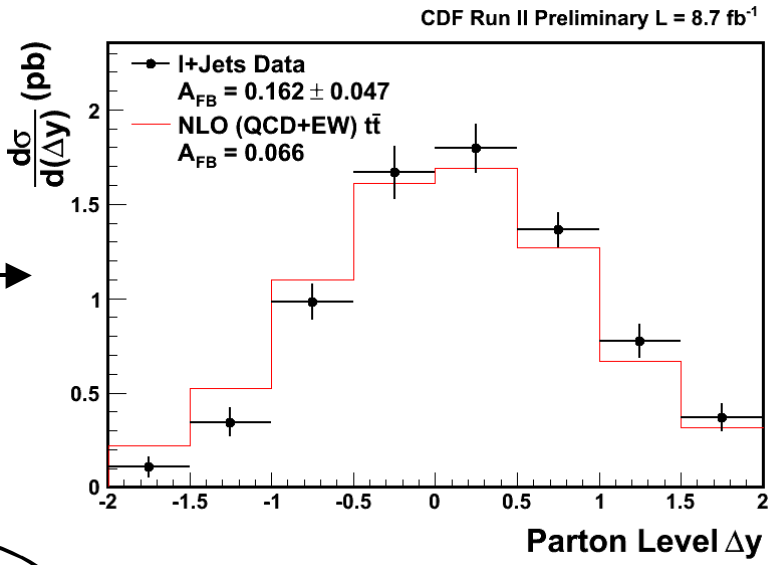

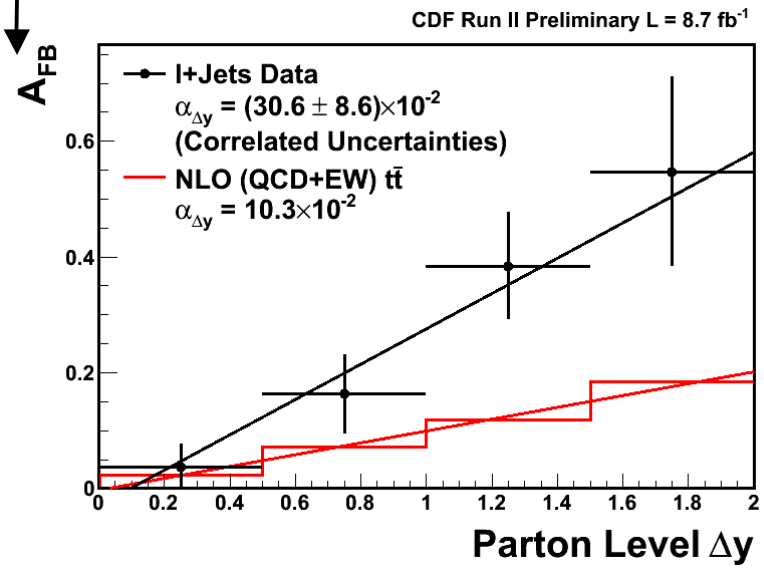

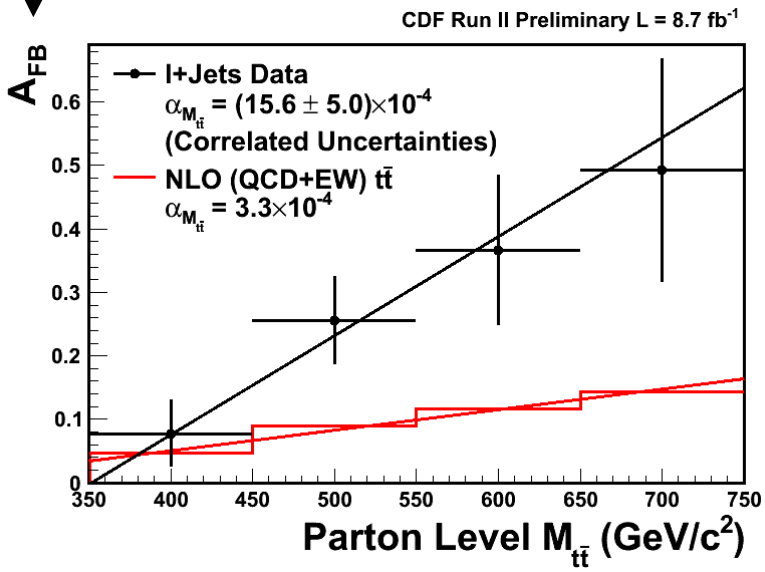

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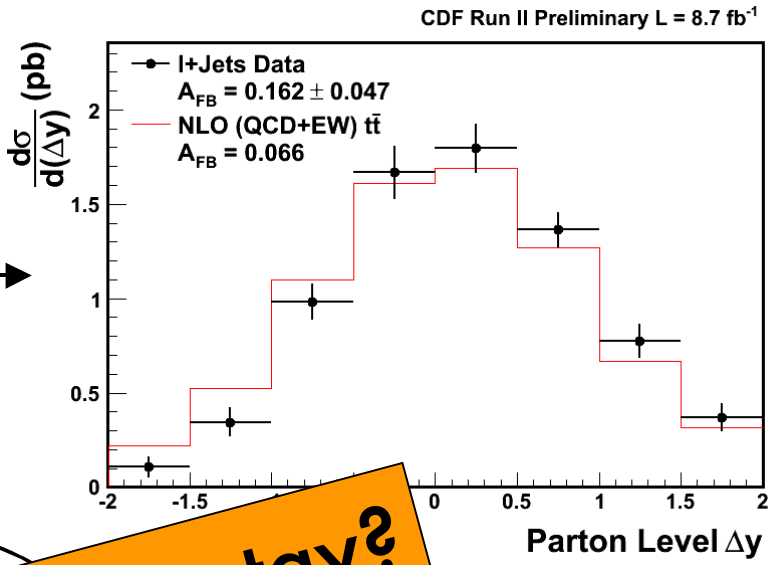
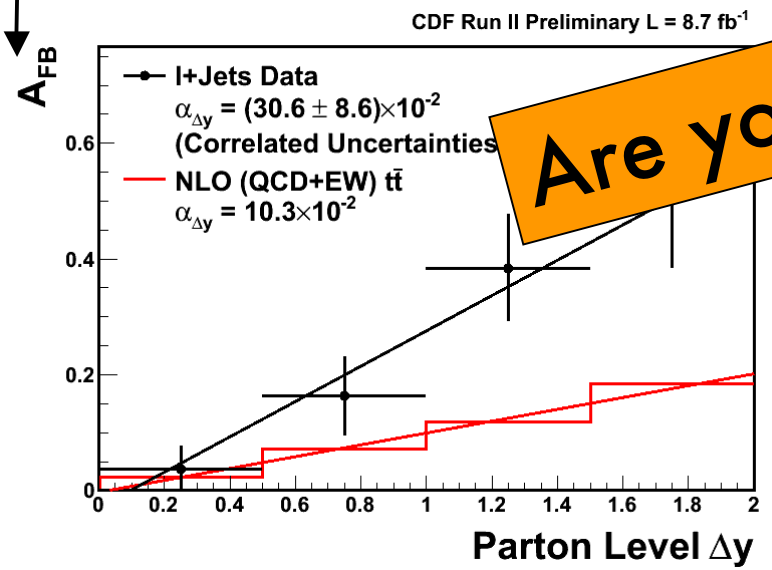
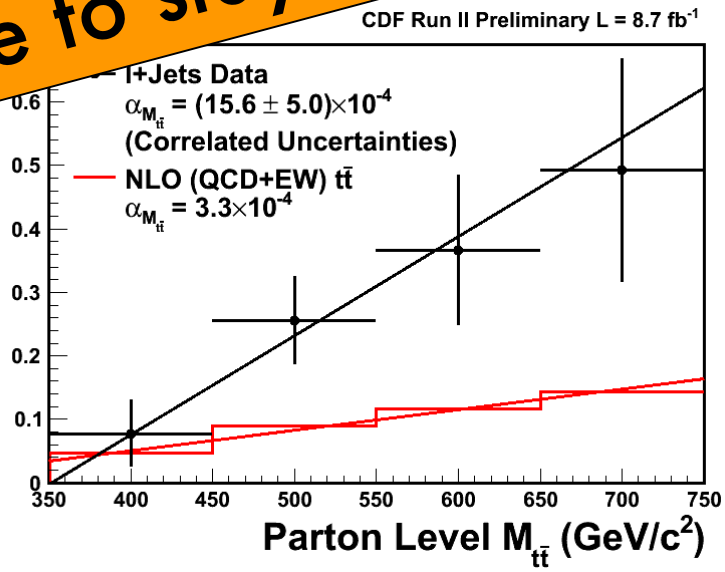


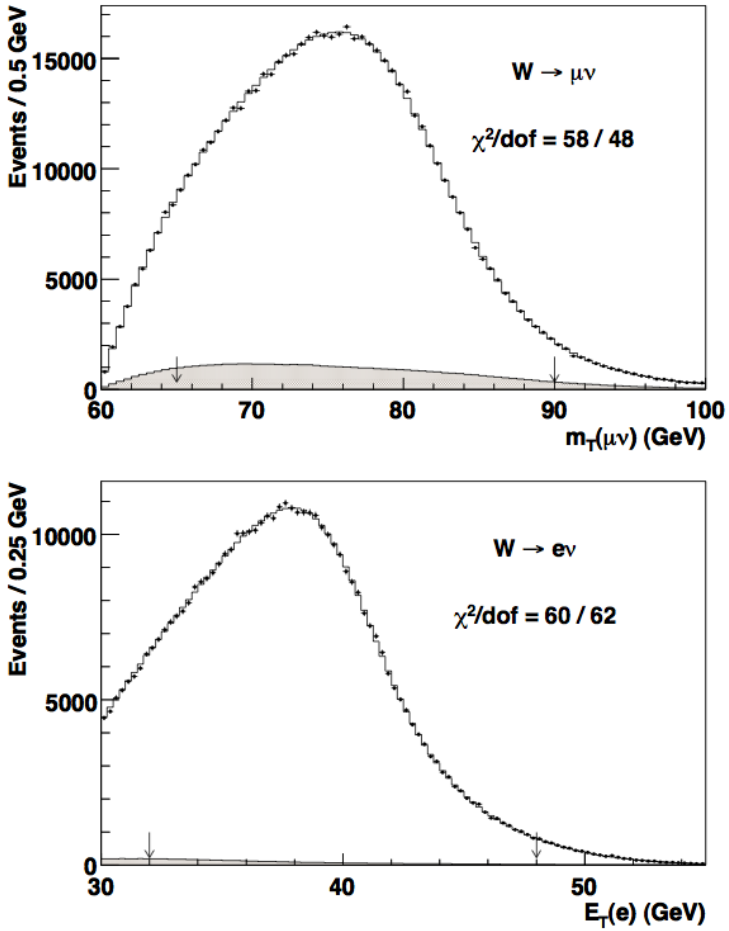


Are you here to stay?



Electroweak

W mass



Fits in m_T, lep p_T , nu p_T as a function of m_W for muons and electrons

Necessary components:

- Production model (QED, PDFs, W pt)
- Track momentum scale (J/ψ, Υ, Z)
- EM Energy scale (calibrate with W and Z E/p)
- Hadronic recoil model (calibrate with Z)
- Background estimation

Combine all six fits

Fore more infos: see A.Kotval W&C seminar on Feb 23, arxiv 1203.0275

W mass

- Impressive amount of work to reduce most source of systematics
- Most precise determination of W mass to date
- Significantly impact the prediction for the Higgs boson mass

Source	Uncertainty (MeV)
Lepton energy scale and resolution	7
Recoil energy scale and resolution	6
Lepton removal	2
Backgrounds	3
$p_T(W)$ model	5
Parton distributions	10
QED radiation	4
W-boson statistics	12
Total	19

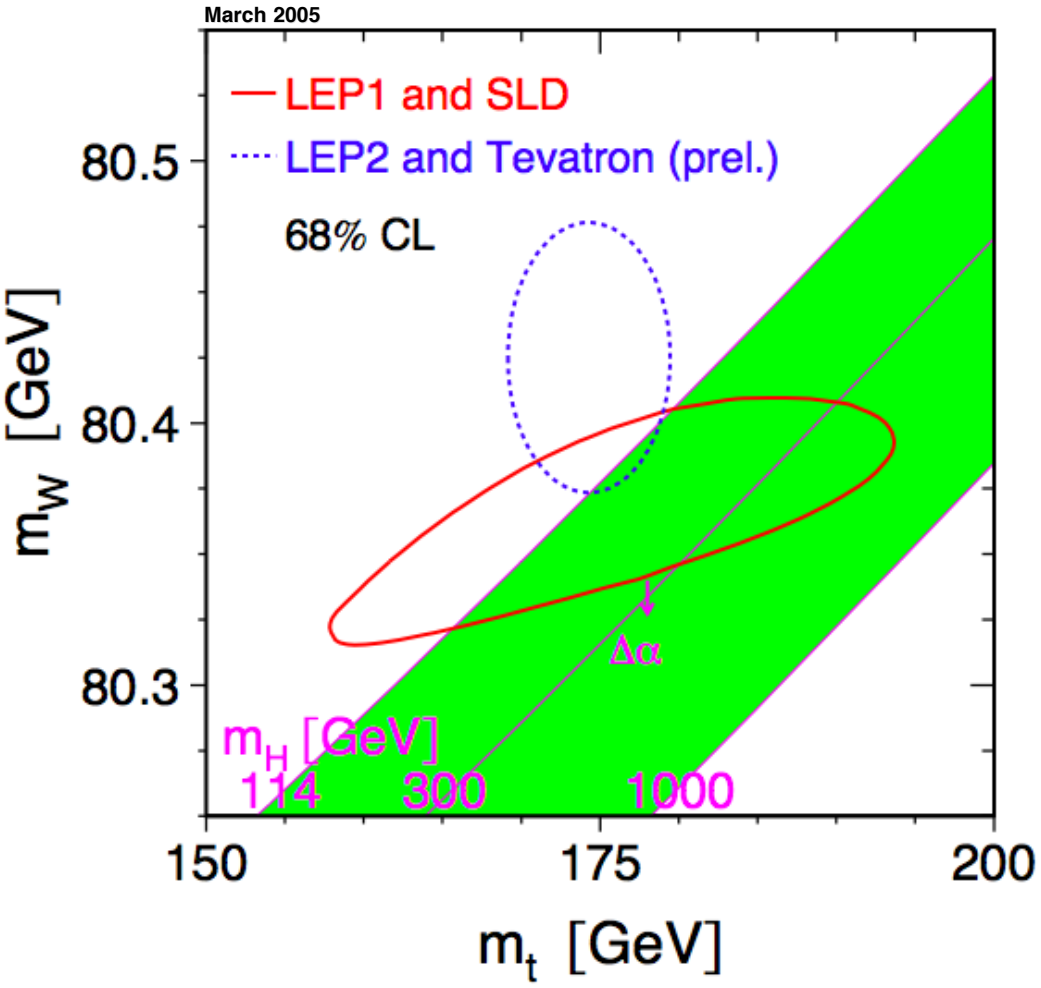
New world average of 80390±16 MeV
Prelim fit of mH = 90+29-23 GeV
mH< 145 GeV @95% CL

Talking about the Higgs boson

From W and top to Higgs

For many years, Tevatron has been leading the Higgs hunt

Continuous improvement in precision of M(W) and Mtop



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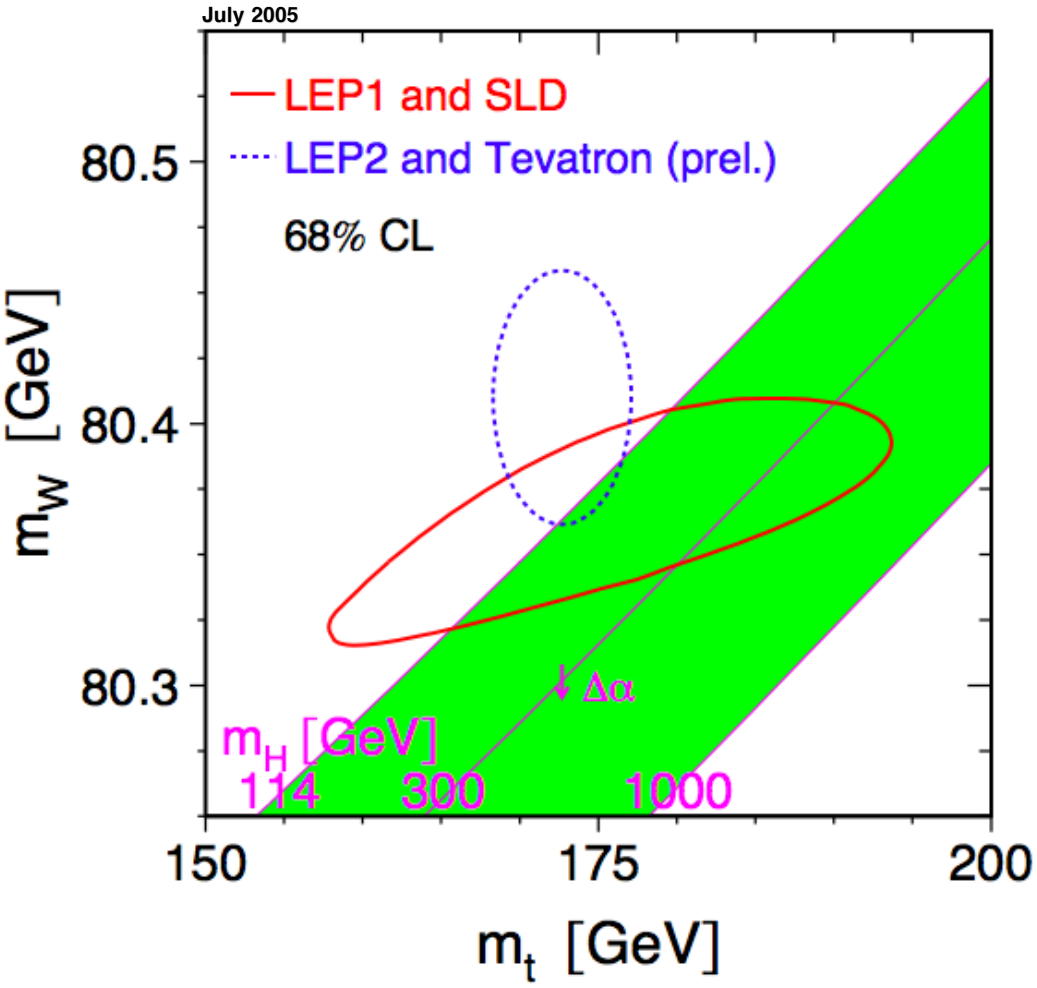

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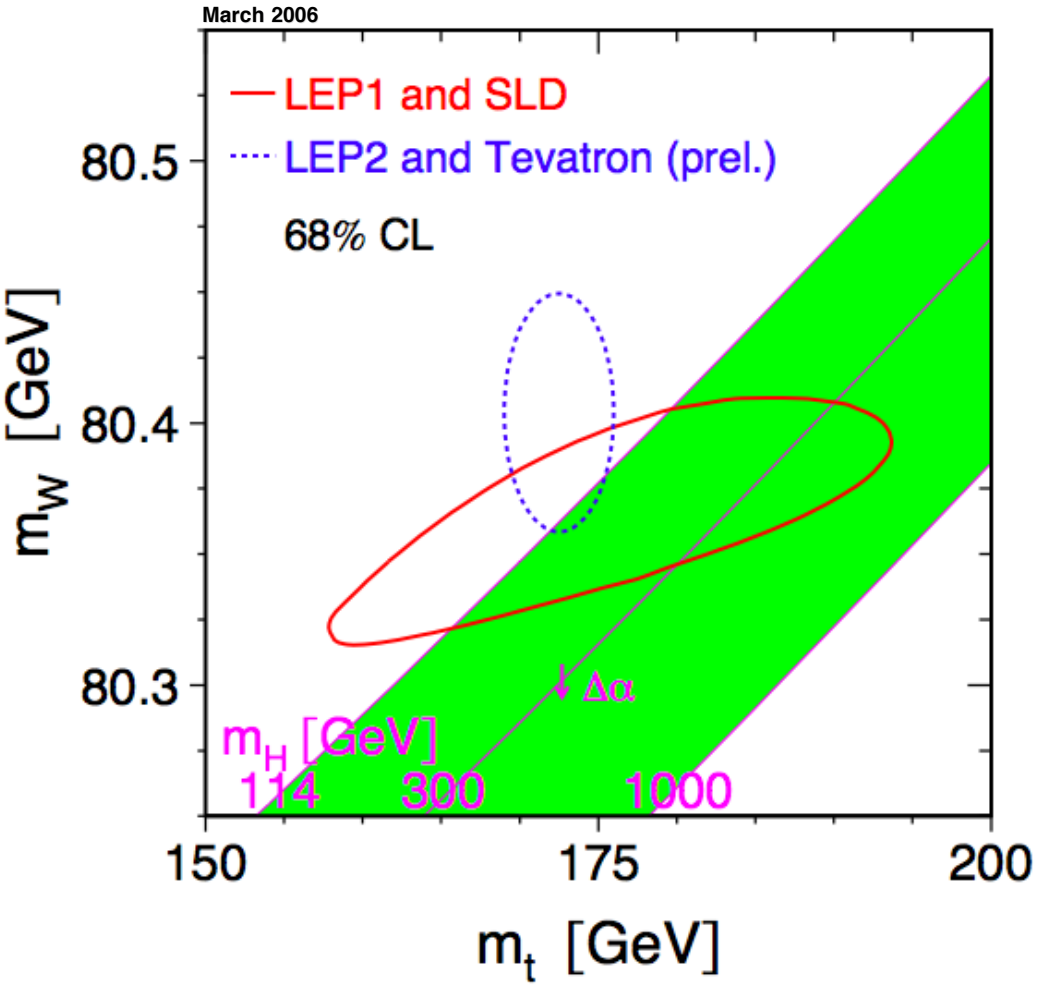

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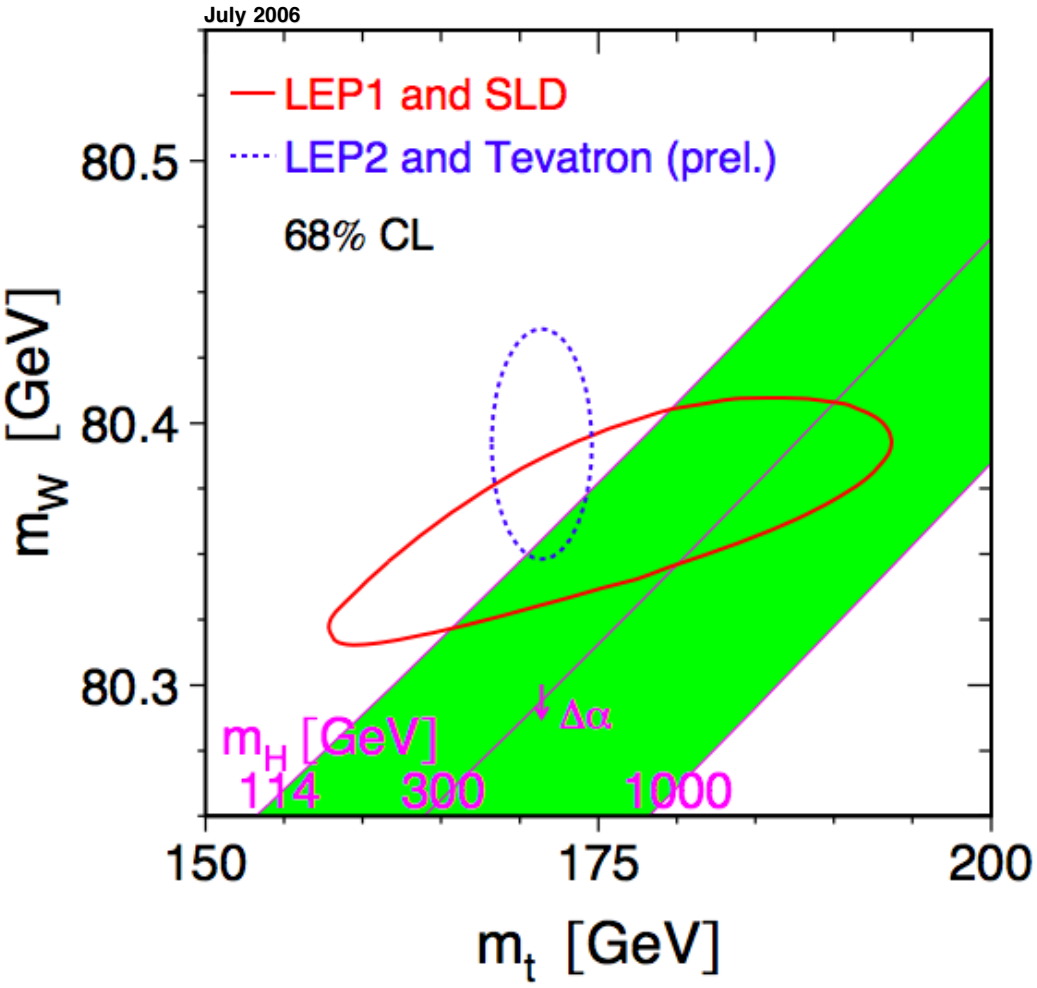

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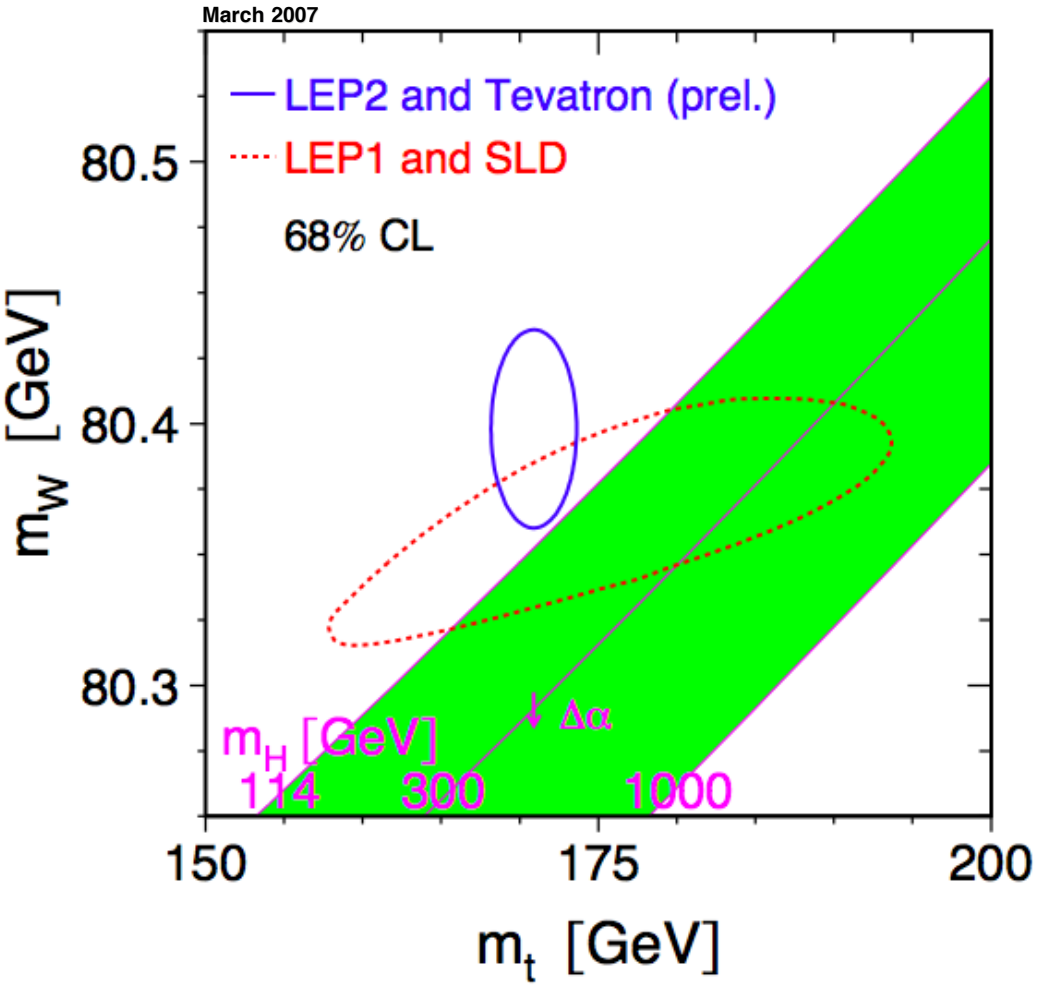

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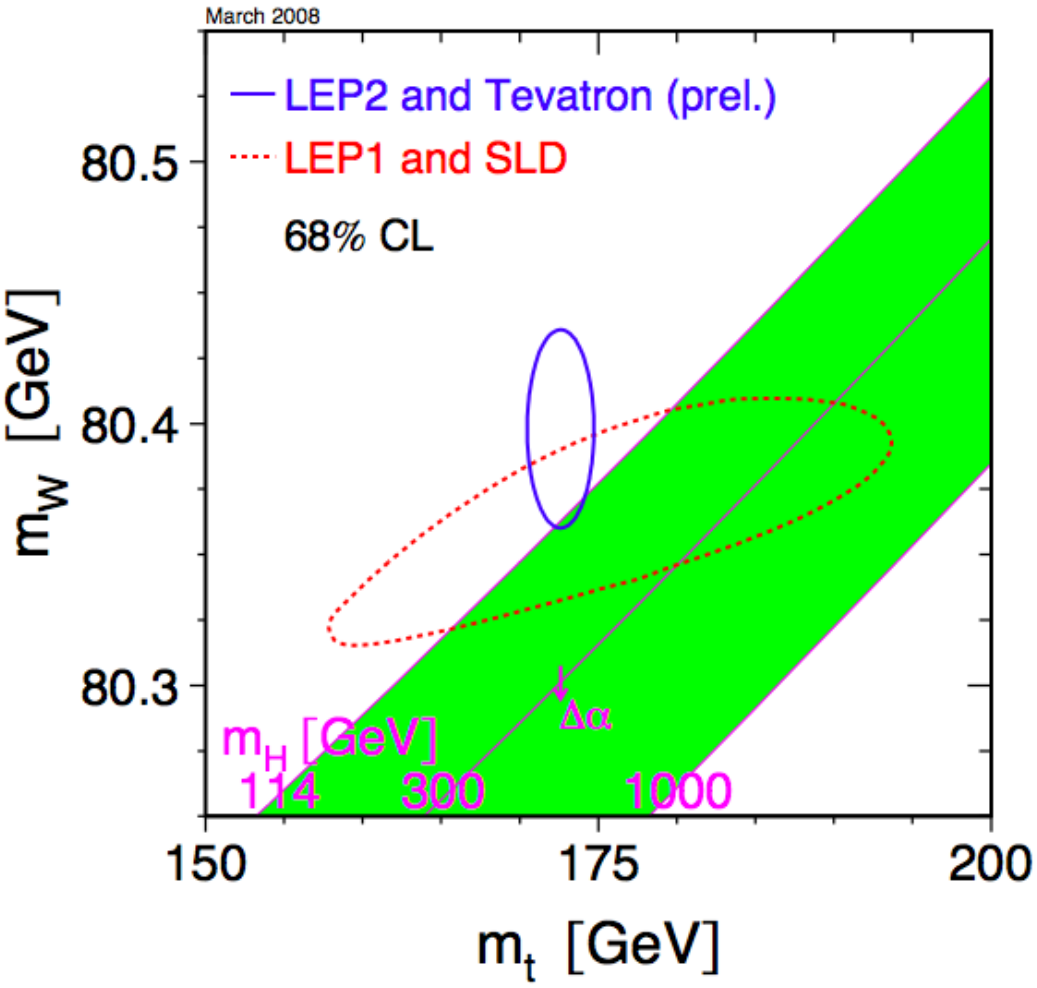

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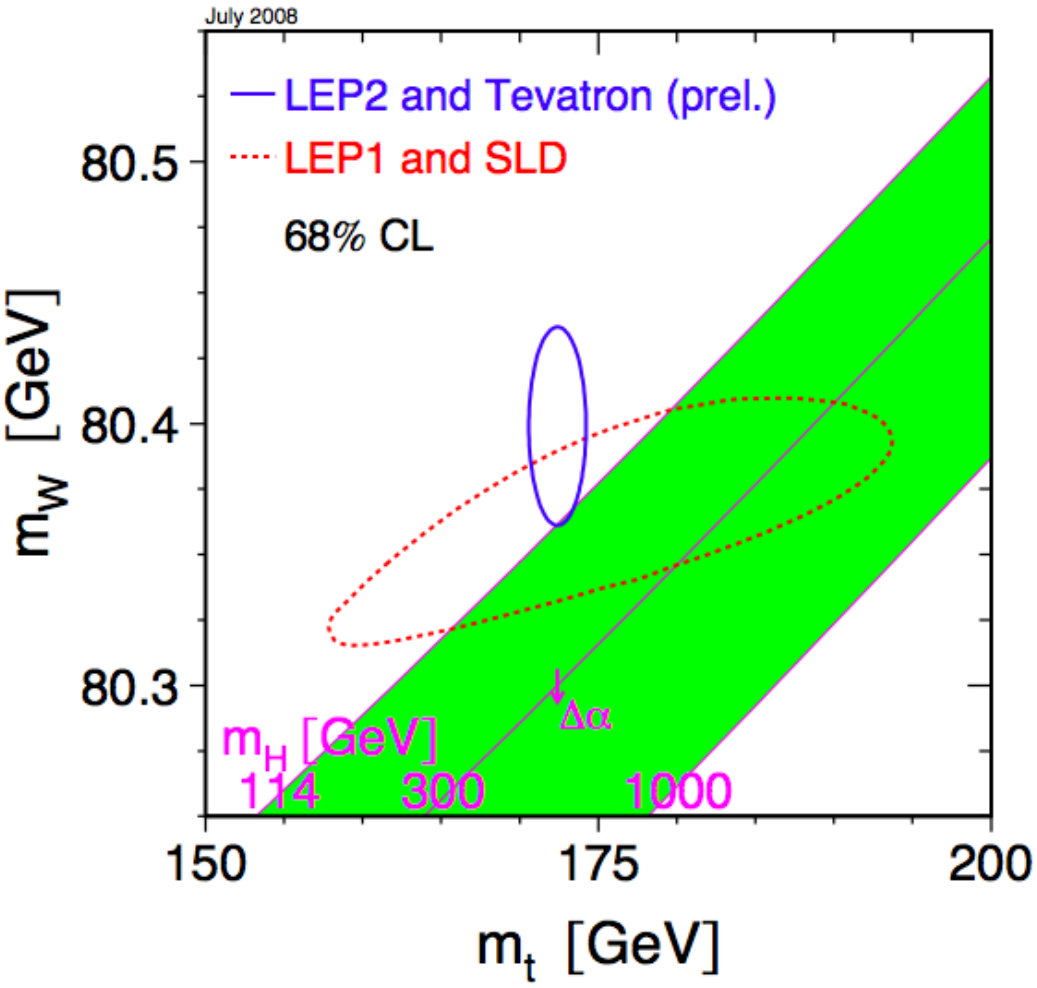

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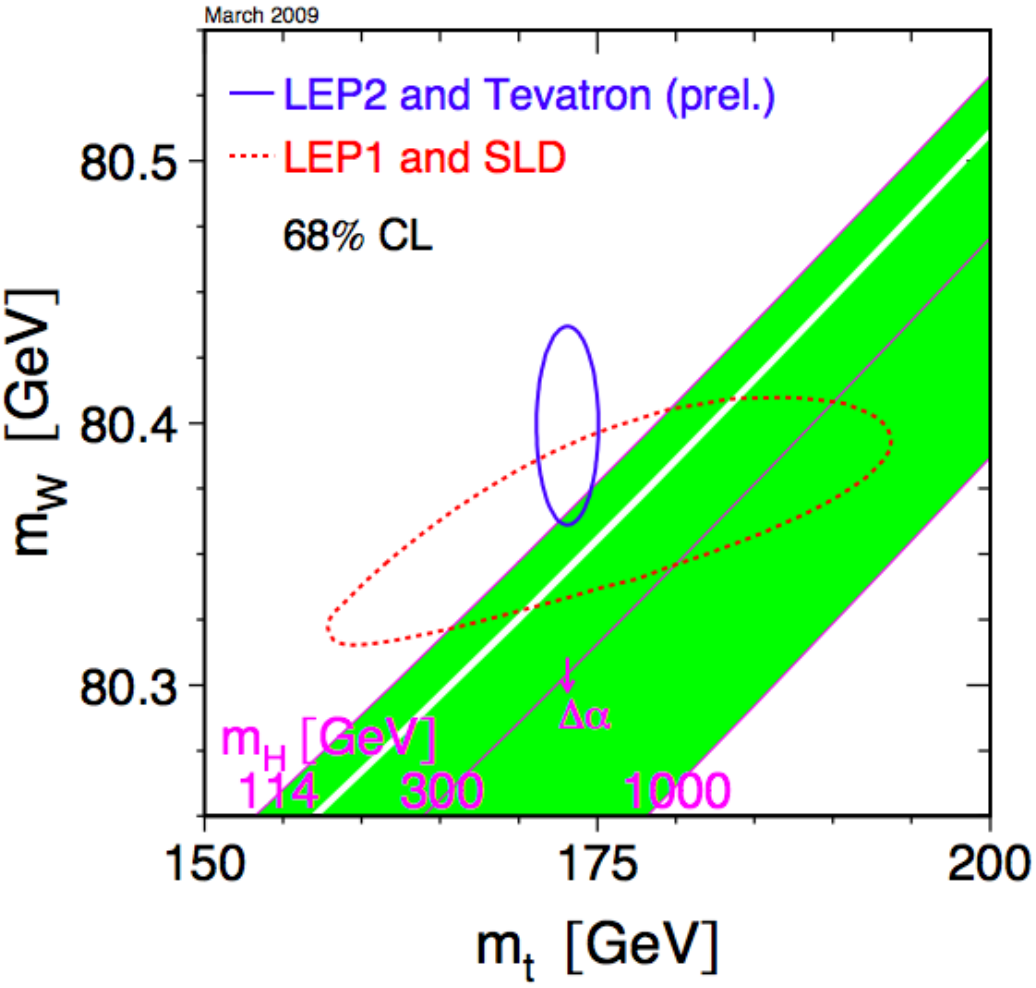

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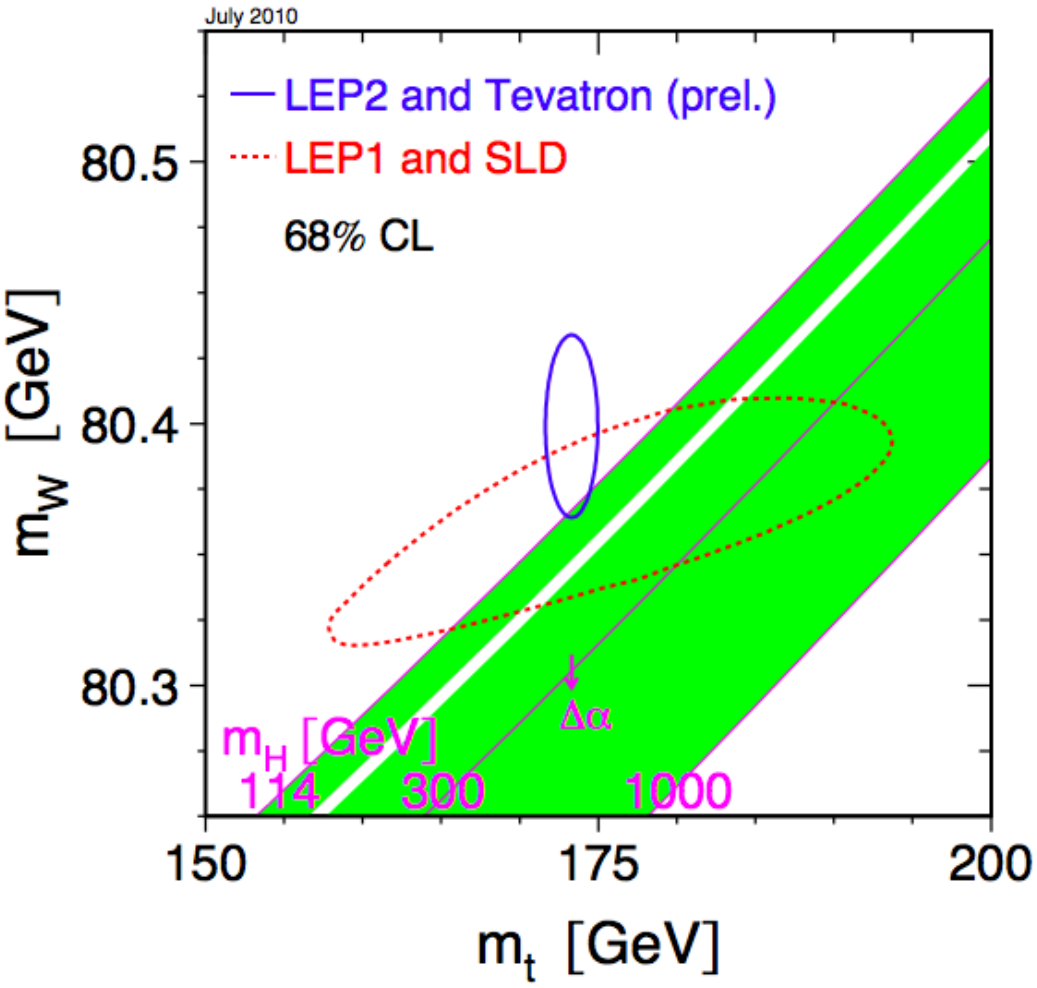

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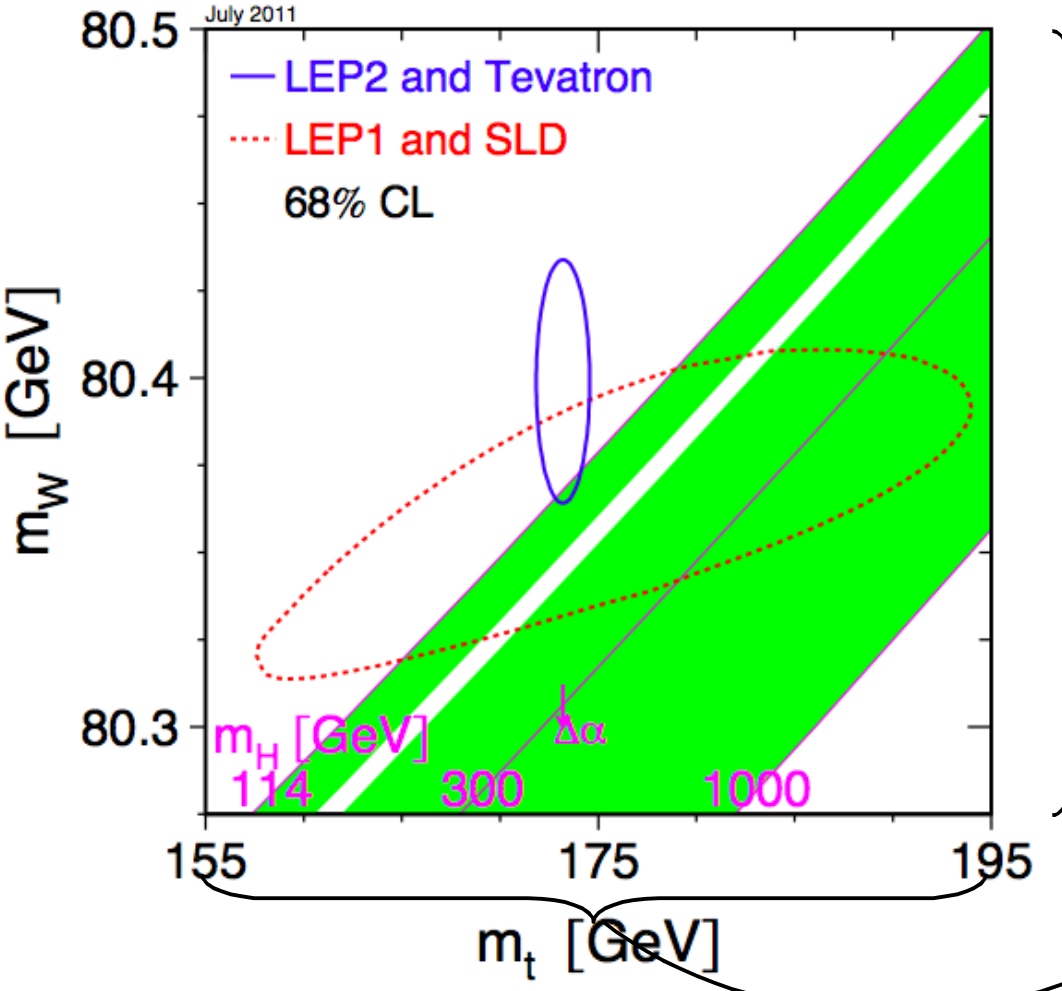

Range on x/y axes now 25% smaller

From W and top to Higgs

Finally, the LHC joined the hunt…

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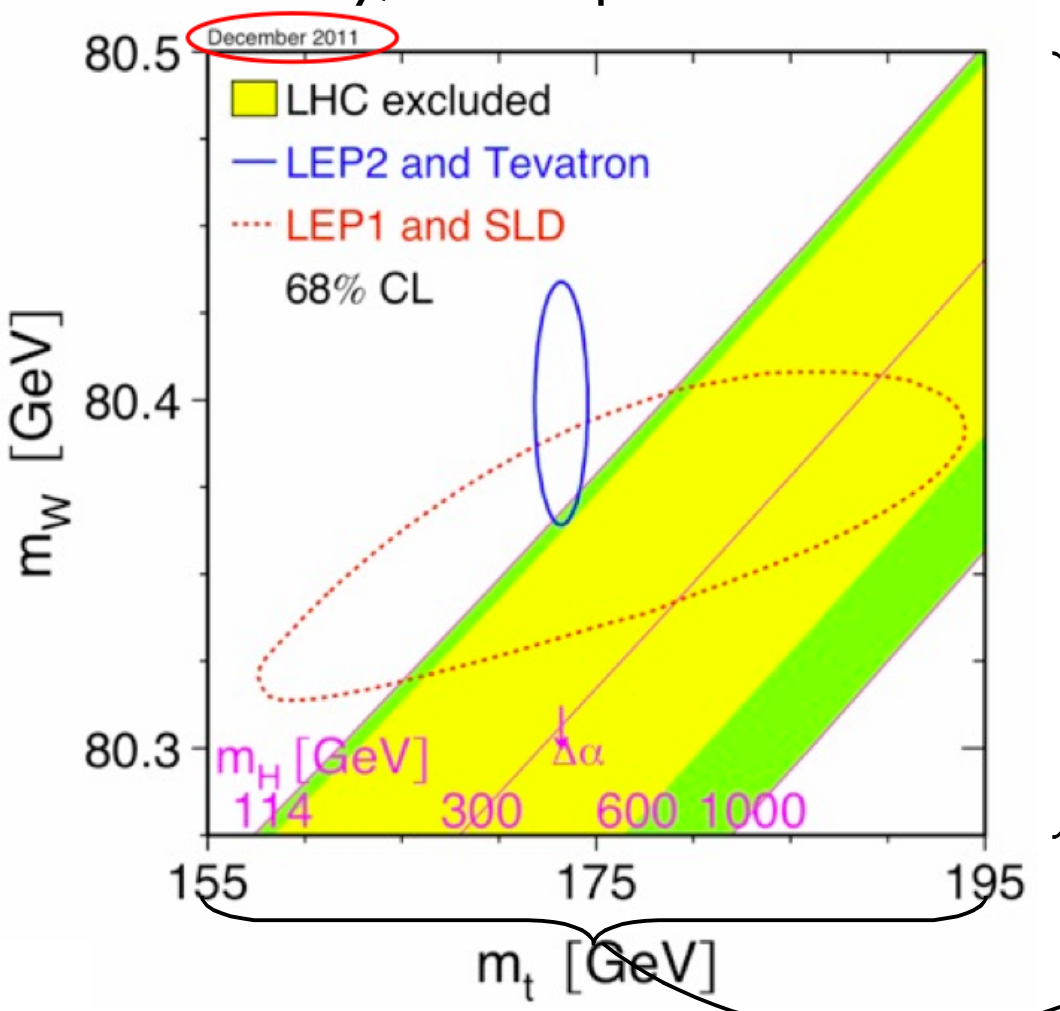

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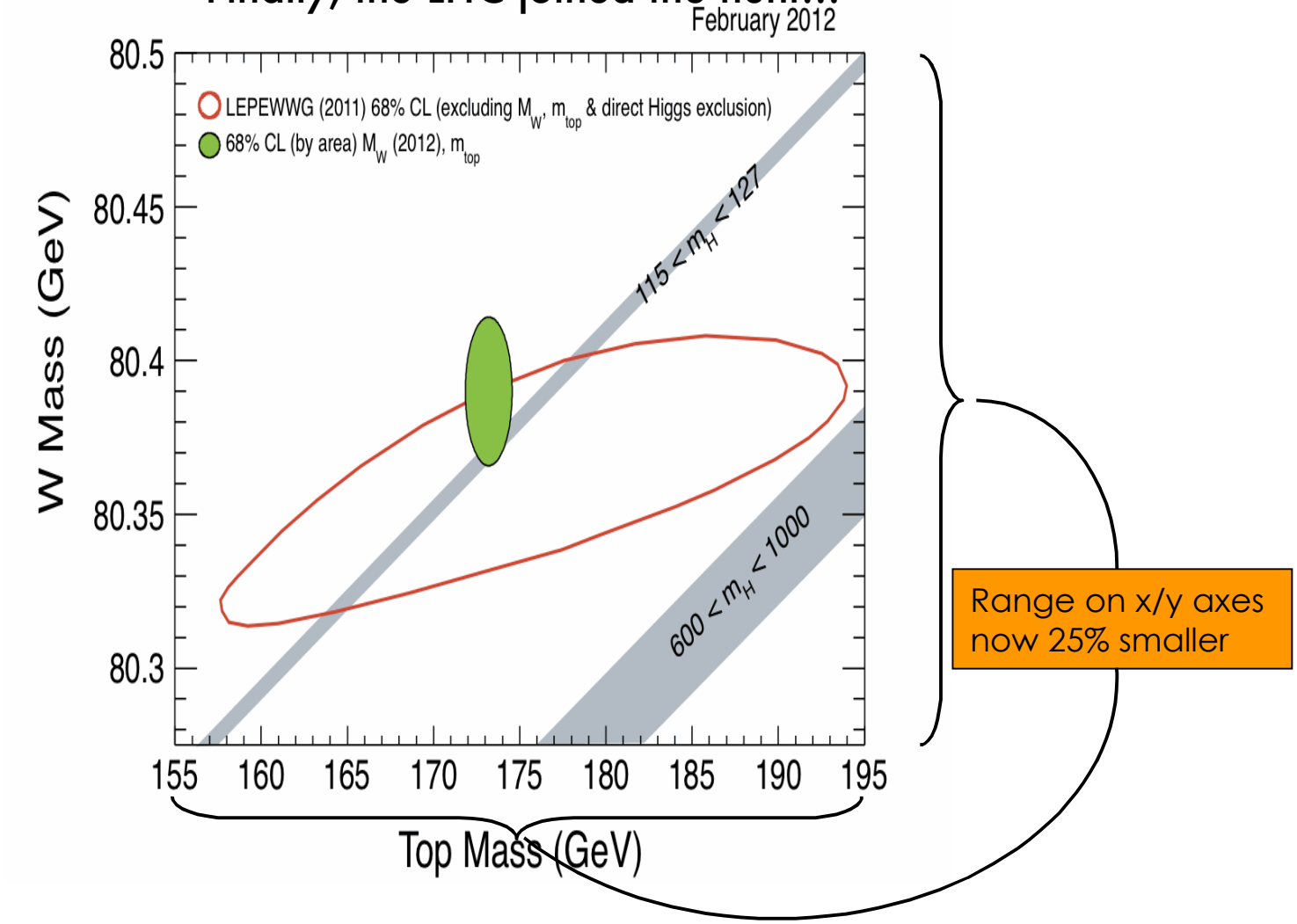

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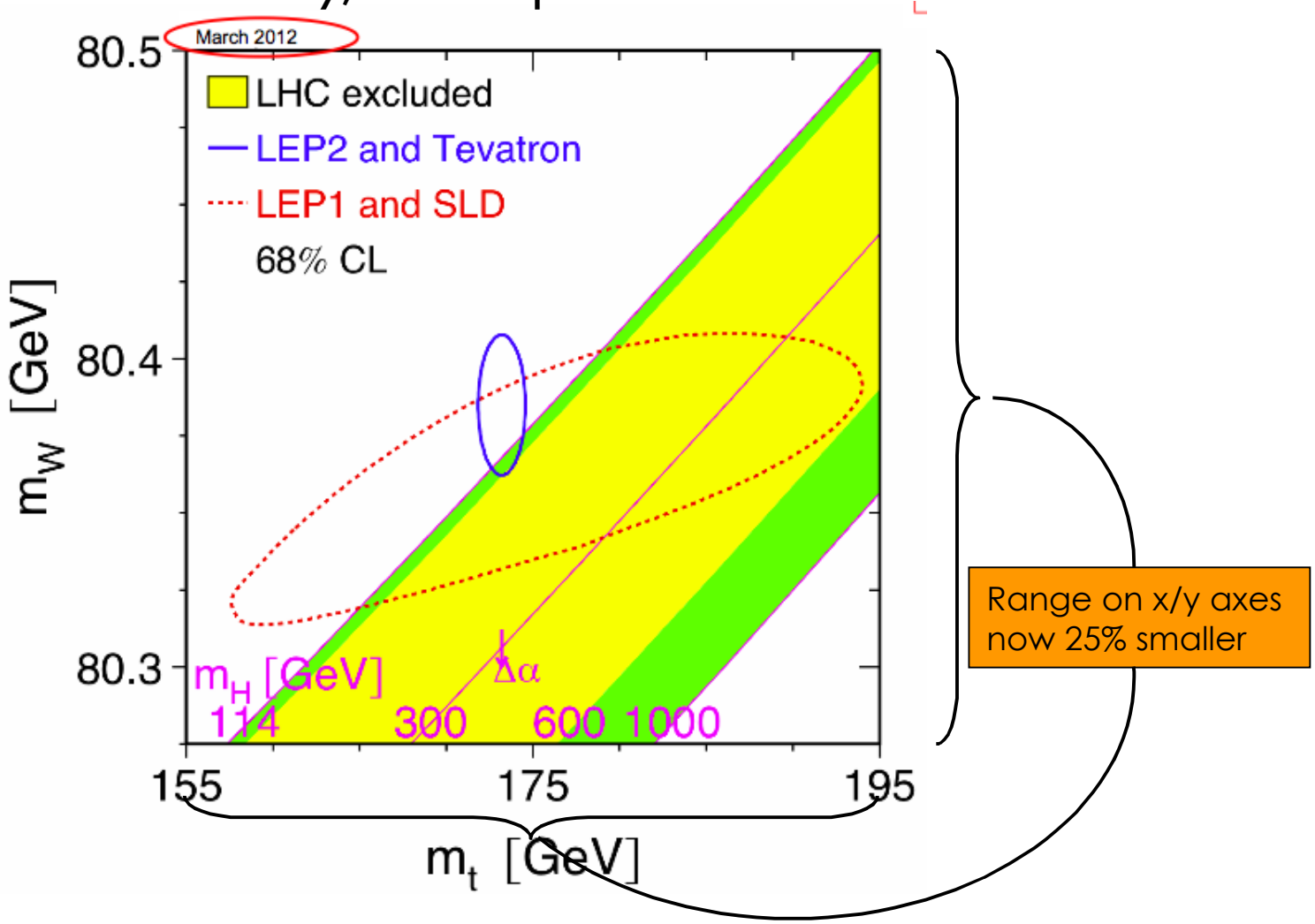

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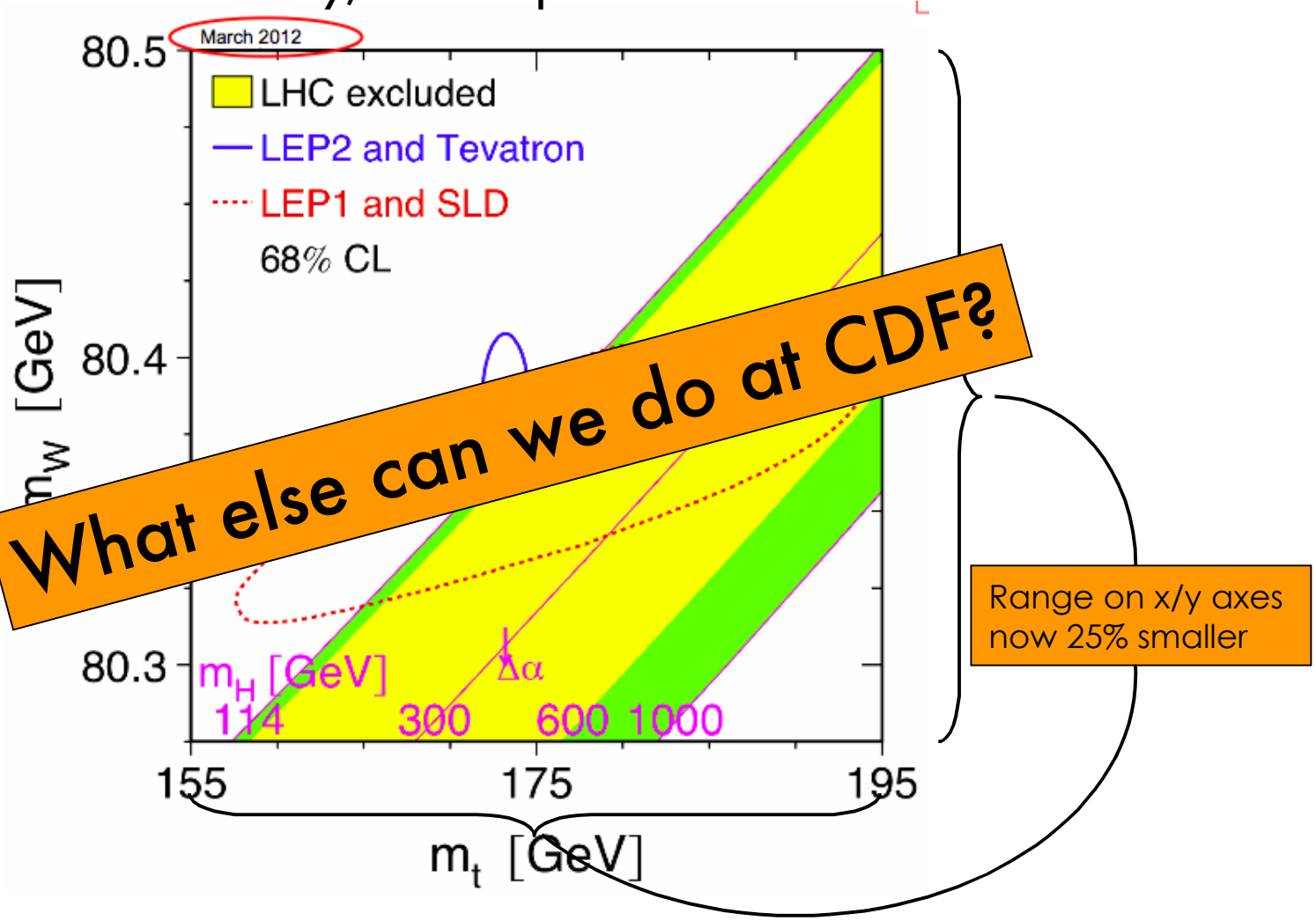
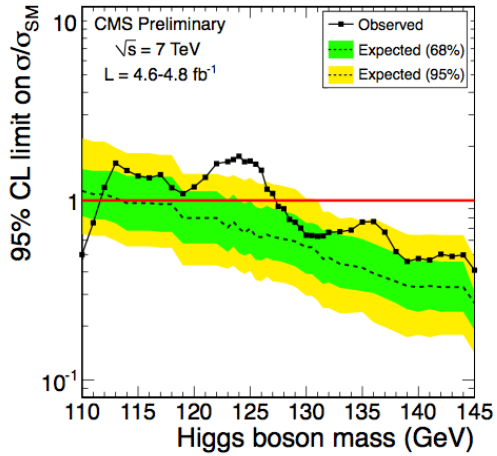


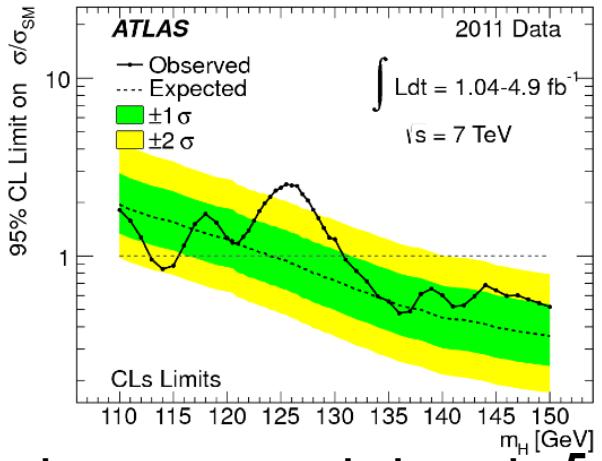
What else can we do at CDF?

Range on x/y axes now 25% smaller

LHC probes H coupling to bosons

- At LHC gg→H cross section much larger, and backgrounds grow little.
  - γγ, WW, ZZ final states most sensitive channels



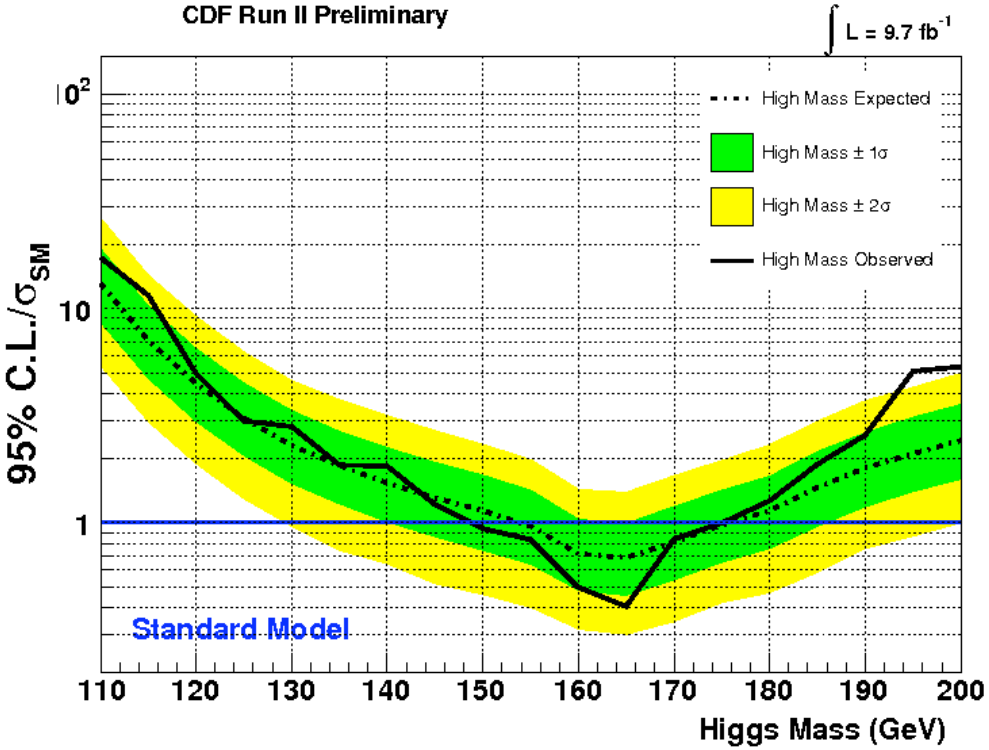


- On the other hand, WH/ZH associated production grows little with √s in pp, and W/Z+jets backgrounds grows fast:where the H → bb decay counts the most

	CDF, D0	Atlas, CMS
H->γγ	10-13*SM	1.5-2*SM
H->WW	~3.5*SM	1-2*SM
H->bb	~2*SM	~3.5*SM

CDF and Higgs decaying to bosons

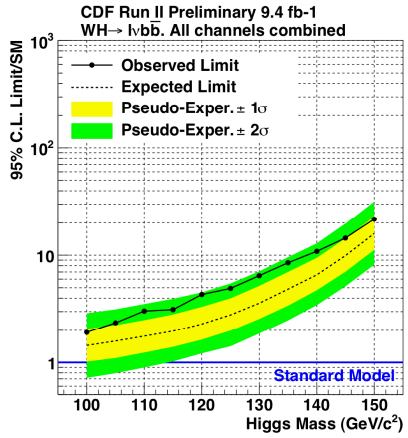
- CDF updated all low mass and high mass Higgs analyses
  - Now analyzing all dataset
  - Improved background discrimination, enhanced signal acceptance,etc.
  - CDF exclusions expanded in the high mass region

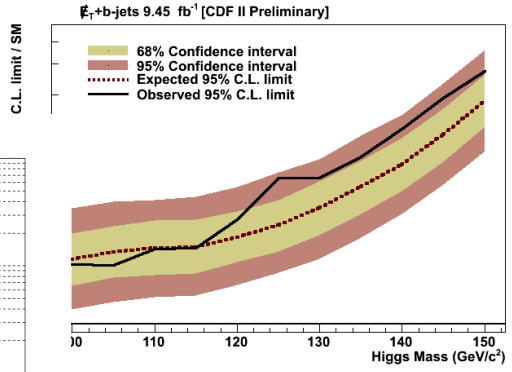


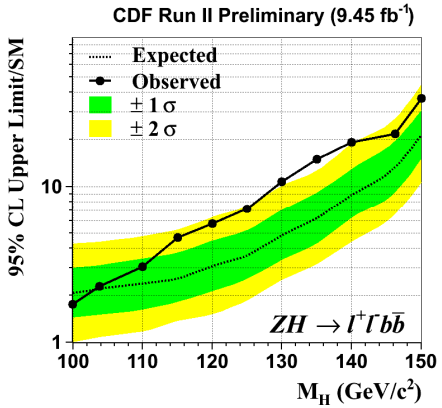
  - please also note that sensitivity @125GeV close to HV searches

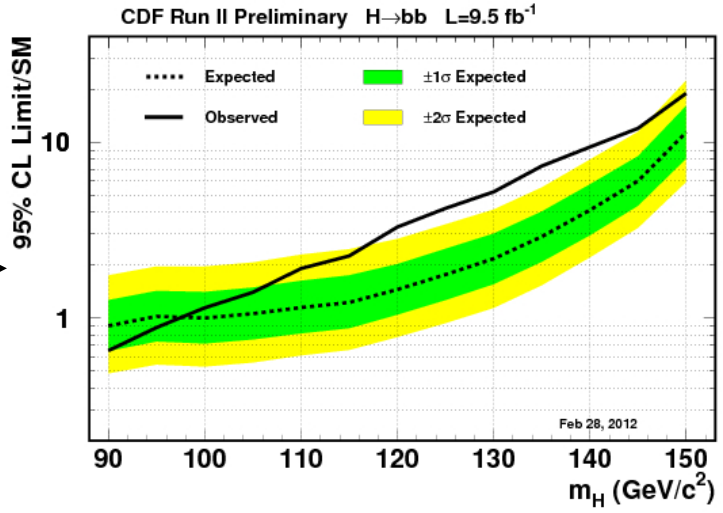
CDF probes H coupling to fermions

- CDF updated all low mass and high mass Higgs analyses
  - Now analyzing all dataset
  - Improved background discrimination
  - Increased acceptance and resolution thanks to new b-tagging, leptons, jets algorithm









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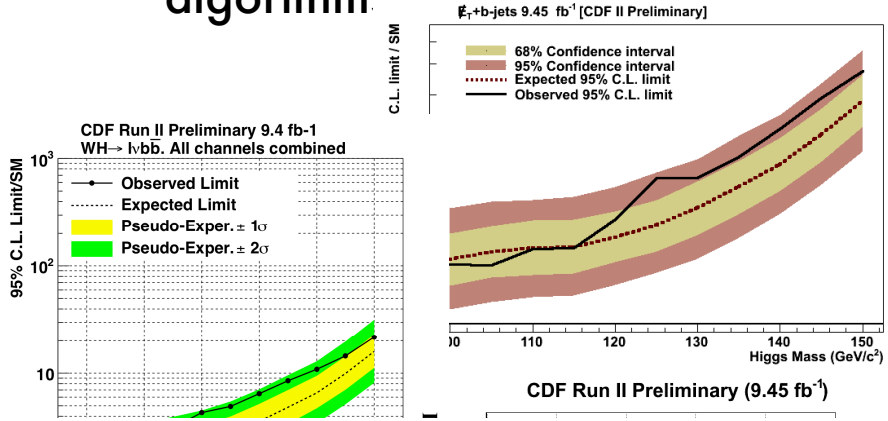
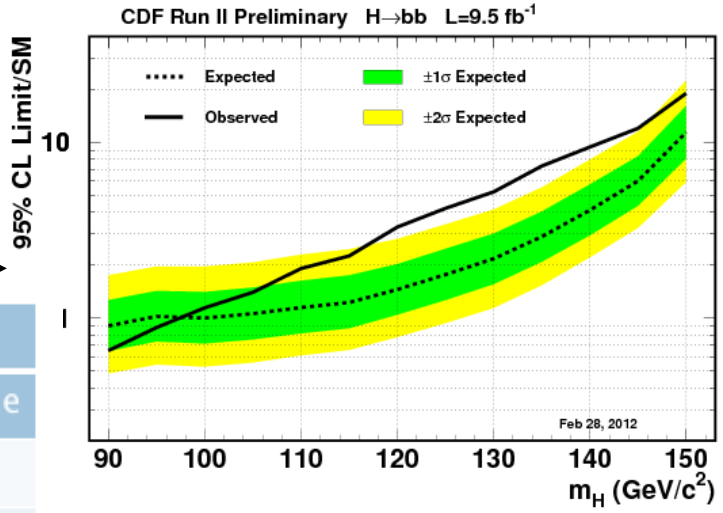
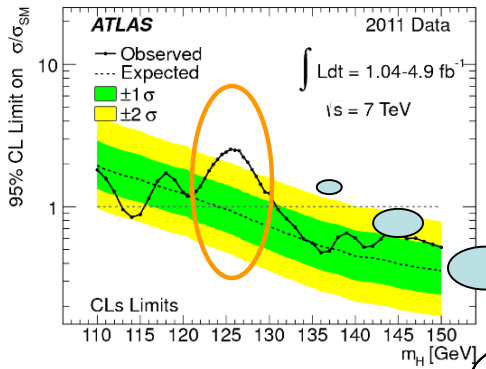


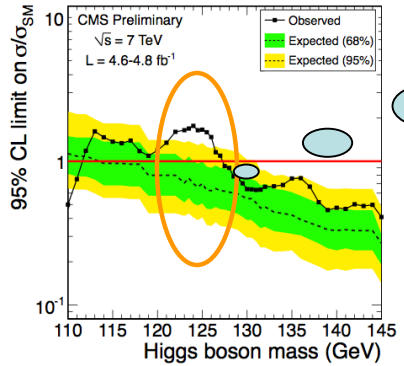


Single Channel Searches			
Experiment	Channel	Local P-value	Global P-value
CDF	H->bb	2.9σ	2.7σ
ATLAS	H->γγ	2.8σ	1.5σ
CMS	H->γγ	3.1σ	1.8σ

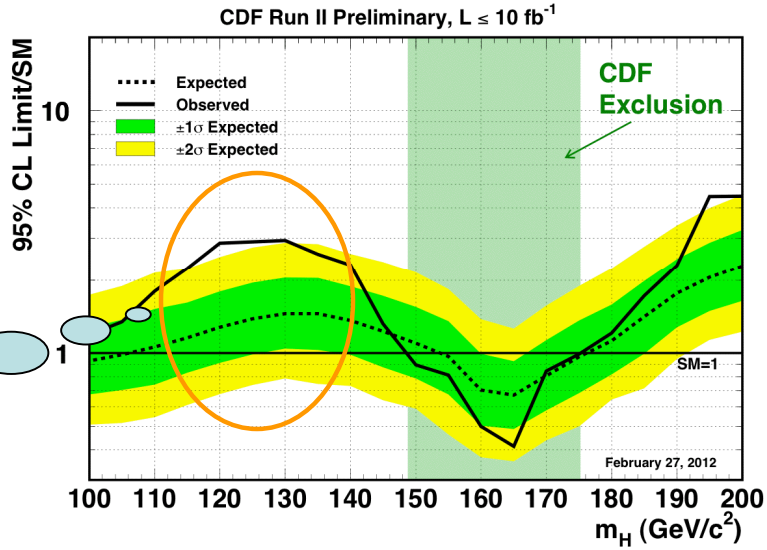
Tev probes H coupling to fermions

- CDF updated all low mass and high mass Higgs analyses
  - Now analyzing all dataset
  - Improved background separation
  - Increased acceptance and resolution thanks to new b-tagging, leptons, jets algorithm





Are these plots talking to each other???



Fore more infos: see M.Stancari W&C seminar on Mar 7


Into the unknown
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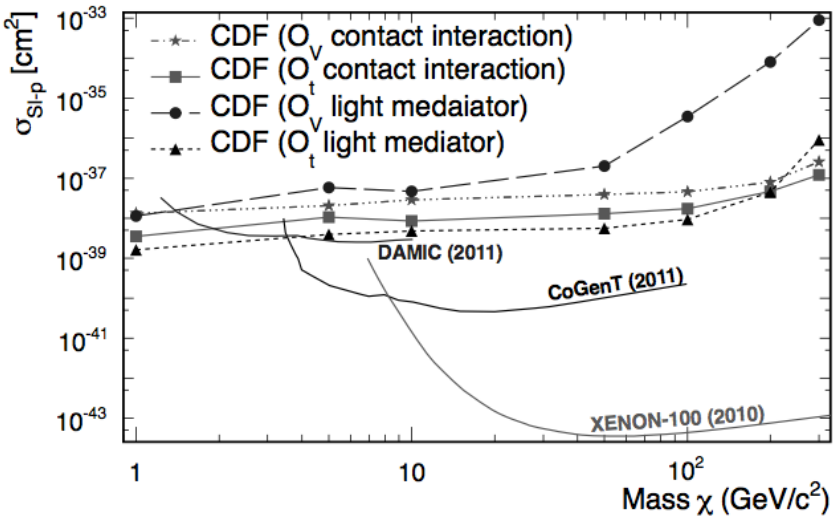
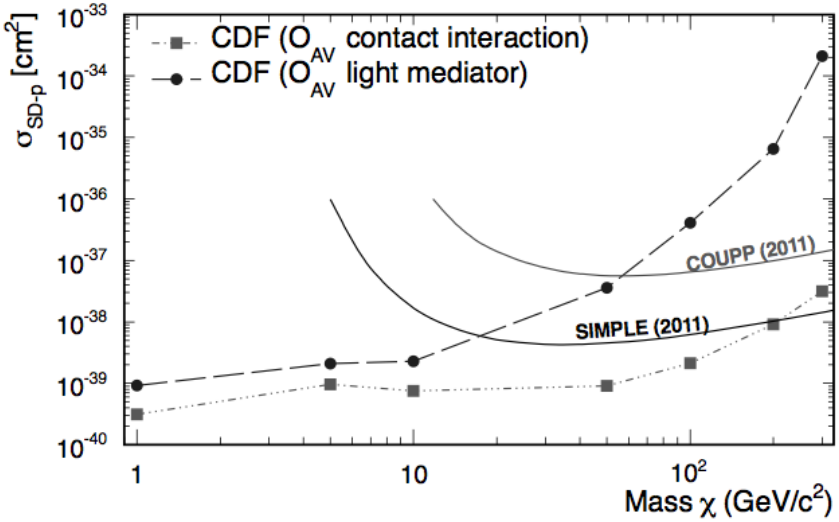
Dark matter in monojet

If dark matter interacts with SM, then colliders are ideal tools for DM production

- Collider advantage #1: no detection threshold
- Collider advantage #2: Insensitive to spin-dependent/spin-indepenent effects





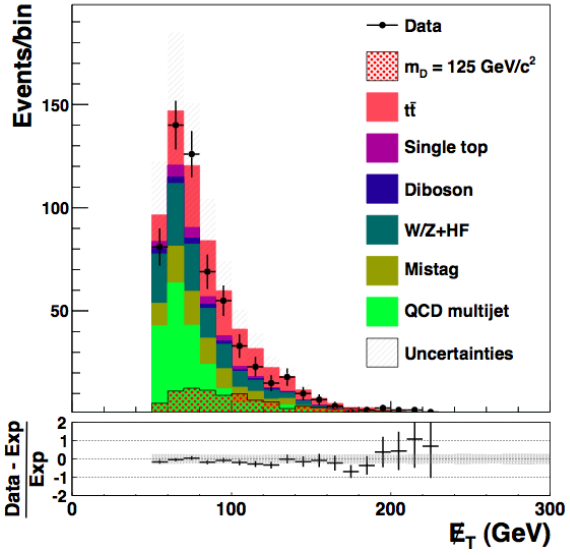
Hadron colliders are competitive with dedicated direct detection facilities!

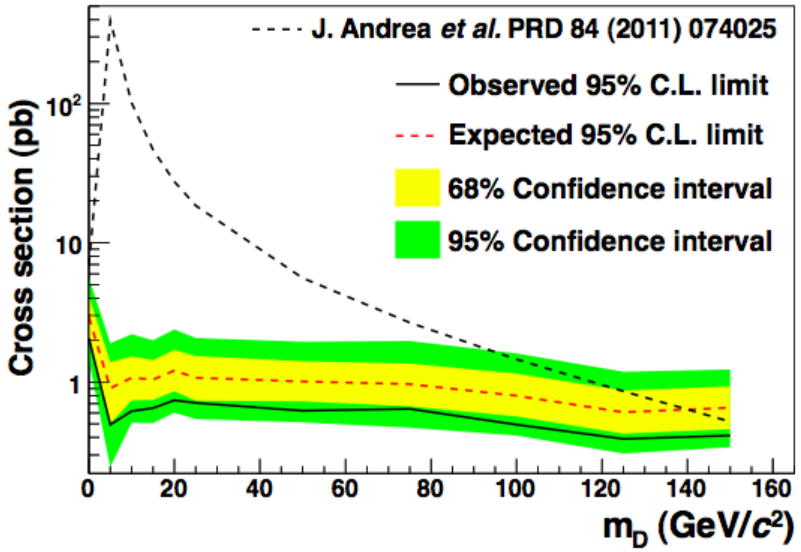
Fore more infos: see S.Shalhout W&C seminar on Jan 20
arxiv 1203.0742

…and monotop

One more signature that has been investigated here for the first time.

- Study events with a single top quark plus large MET.
  - Can arise from FV models, SUSY etc.



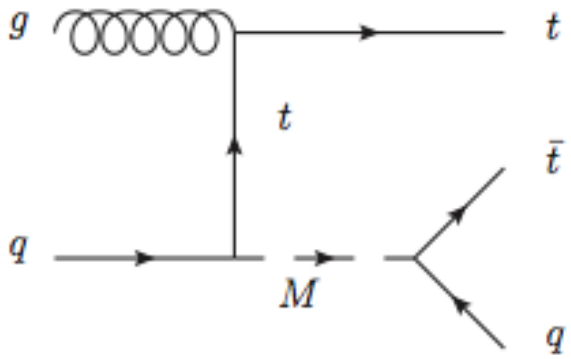


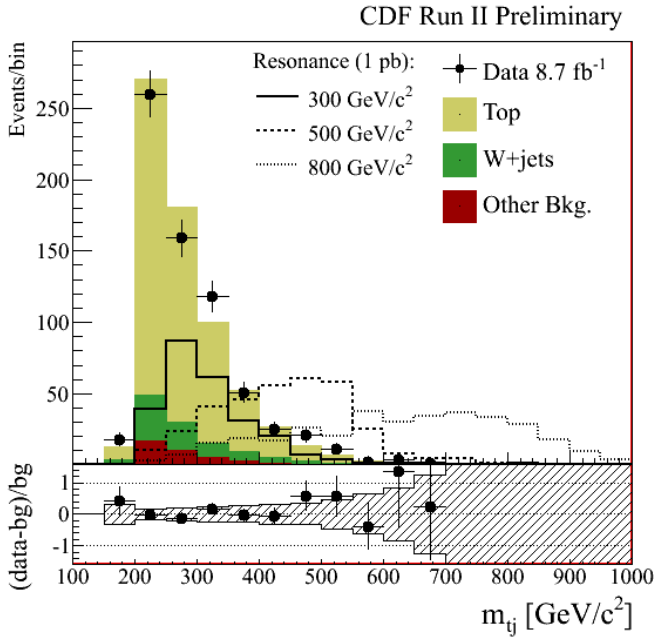
No signal seen, set limits on cross section in a model with mediator D

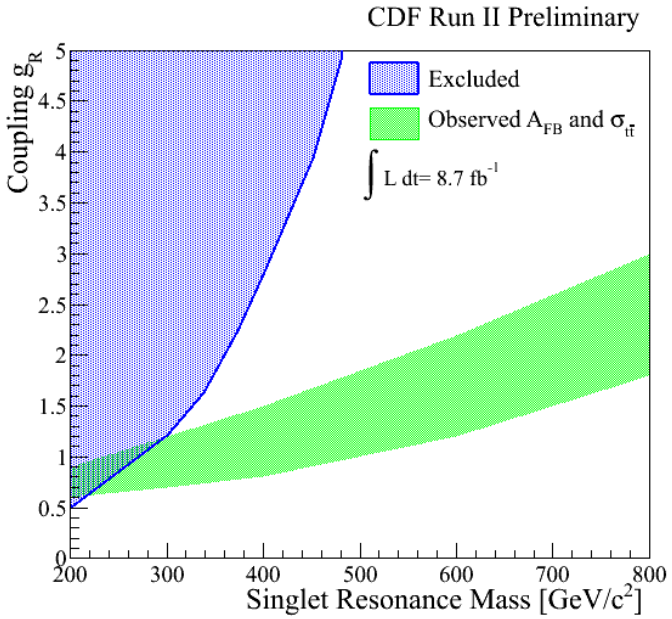
arXiv:1202.5653, submitted to PRL

More exotics involving top quarks

- Anomalous top AFB could be explained by a new particle Z′ with uZ′t coupling. Would give rise to
  - Same sign top production (already investigated)
  - Search tZ′ →ttj events for resonant top+jet production







Bagged but not shown here

Y spin alignment
Ds fragmentation
Bs → Ds(*)+ Ds(*)-
Measurement of CP violation in D0 --> Ks pi+pi-:
B_c lifetime measurement
W helicity dilepton pretag/tagged
Ttbar spin correlation in dilepton
Measurement of BR(t->Wb)
Z Pt boson spectrum
W+charm cross section
New physics in same sign dilepton with taus
New physics in trilepton events
+ a slew of Higgs results presented last week!

Please check them at the following address
http://www-cdf.fnal.gov/physics/W12CDFResults.html

Conclusions

- Impressive amount of physics for an experiment reaching his 30s

- We are in a complex era, but one where CDF still playing a high profile role:
  - world best determination of key SM measurements
  - Other measurements taking advantage of the unique ppbar collisions
  - Test bed for exciting ideas: dark matter detection now a colliders realm!
- Competitive with b-factories, t-factories, DM, Higgs facilities!

- *This is again an exciting time for particle physics:*
  - *Higgs might be around the corner*
  - *Interesting deviations observed by multiple experiments*

Conclusions

- Impressive amount of physics for an experiment reaching his 30s

- We are in a complex era, but one where CDF still playing a high profile role:
  - world best determination of key SM measurements
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